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THE

STUDENT

AND

INTELLECTUAL OBSERVER

OF

SCIENCE, LITERATURE AND ART.

VOLUME V.

ILLUSTRATED WITH PLATES IN COLOURS AND TINTS AND NUMEROUS ENGRAVINGS ON WOOD

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THE CONDITION OF JUPITER.

BY JOHN BROWNING, F.R.A.S.

(*With a Coloured Plate.*)

When Jupiter is observed continuously by the aid of a telescope of three or four inches aperture, it will be found that the bright and dark belts which encompass his great globe, change from time to time in form and number.

With instruments of large aperture, and higher power, the dark belts will be found sometimes to vary in colour.

I must here lay great stress on *high power*. The colours on Jupiter and Saturn are scarcely ever perceptible with powers below 100, and they are only to be seen advantageously with powers between 250 and 500. Using such powers as these, the dark belts, which are mostly of a pearly, or, at most, a warm grey, will frequently be found of a coppery hue, oftener still they are a deep purplish red.

I would here remark that the stars, being exceedingly bright, their colours may be well seen with telescopes of small aperture, using a power which will magnify the disc to an appreciable diameter; but for observations on the colours of the planets, especially Jupiter and Saturn, whose light is faint, much fainter than that of Venus and Mars, recourse must be had to moderately high powers, and telescopes of very large aperture.*

With regard to the colour of the red belts and their changes,

* I cannot explain why a combination of large with high power should be effective in showing colour on planets, but several well-known observers agree with me that this is the case.

these phenomena seem to be due to some peculiarity of the planet itself, for I have frequently observed the belts display the greatest amount of colour when our atmosphere was very clear and free from mist. If the colour were due to changes in our own atmosphere, the reverse would be the case. In the drawing here copied the belts were coloured with a mixture of madder-brown and sepia; but two years since, I saw them of a full rich claret colour, the colour of pure purple madder.

While these changes occur in the colour of the dark belts, the bright belts remain for years unchanged, shining with a silvery light; the great equatorial belt, which has a mean breadth of about 20,000 miles, being almost invariably the brightest portion of the planet's disc.

During the last few months this equatorial belt, generally so free from colour, has been more strongly coloured than any other part of the planet. In the early part of the autumn of last year it appeared to be a greenish yellow. This colour deepened in October to a full ochreish yellow, and now in January, 1870, it is still of the same colour, or perhaps a yet darker tint, rather more of an orange hue than Roman-ochre. Since the apparition of the ochreish belt, the red belts have not exhibited their maximum of colour.

On the evening on which the drawing represented in the engraving was made, the ochreish colour was faintly visible on the first bright belt north of the equator, but I have not seen this colour excepting in the equatorial belt either before or since. Since the change has taken place in its colour, the brightness of the equatorial belt has considerably diminished, it being now very inferior in brilliancy to the narrower bright belts on the north and south of it. Beyond these narrow belts, that is nearer the north and south poles of the planet, the colour is almost uniformly of a blueish grey, rather warmer than ultramarine ash. No change in the colour of these parts has been noticed.

Such a change in colour as that just described indicates the occurrence of some great physical change on the planet. In attempting to account for such a change, we must consider, briefly, how the planet is situated.

Jupiter exceeds in bulk the whole of the members of the solar system excepting the Sun. The effect that the enormous size of the planet has had upon its present condition, has perhaps scarcely received sufficient attention.

In one of the notes appended to his "Saturn and its System,"

Mr. Proctor has suggested that the arid aspect of the Moon is due to the fact, that not only the water, but the gases, which formerly composed its atmosphere, have by intense cold, been frozen into the solid state. This suggestion will enable us to account completely for most of the phenomena observed on the Moon, with the exception of some obscure changes in colour which require and deserve more attention than they have yet received.

Now supposing Mr. Proctor to be correct, it can scarcely be doubted that the small size of our satellite is the cause of its exeedingly low temperature; the whole of its initial heat having been lost in the intense cold of space, the temperature of space, I believe, having been estimated at 130° below zero.

In Mars we have a planet more than double the diameter of the Moon, and little more than half the diameter of the Earth, situated more than half as far again from the Sun as the Earth is.

Unless other circumstances have interfered, such a planet will have lost more of its initial heat than the Earth, though less than the Moon; and accordingly we find near the poles of Mars, ice-caps much larger, in proportion to the size of the planet, than the ice fields of our own polar regions.

Venus, nearly the same size as the Earth, has a dense vaporous atmosphere.

Mercury, midway between the Moon and Mars in size, presents, as might be anticipated, some resemblance to the Moon. Messrs. De La Rue, Huggins, and other observers, having made out markings, like the lunar craters, of a dazzling whiteness. These were seen very indistinctly as through a veil of mist. Indeed the vaporous envelope can always be seen when the planet is in transit, in front of the solar disc. *

Considering the size of Venus and Mercury, we should expect them to have cooled below the temperature of the Earth, but the temperature of both these planets may be maintained by their proximity to the Sun. Mr. Proctor has recently estimated the temperature produced by the Sun shining on Mercury, assumed to have an atmosphere of moderate extent, as far higher than the boiling point of water.*

But Jupiter has a diameter of nearly 89,000 miles, and has a volume three hundred times larger than the Earth. Reasoning from what we know of the condition of the Moon, Mars, and the

* Much highly interesting information on this and kindred subjects, will be found in Mr. Proctor's new work on the planets, now in the press, and shortly to be issued by Longman and Co.

Earth, we may imagine, then, that Jupiter is still at so high a temperature, that water cannot remain in a liquid state on his surface. This suggestion receives support from the fact that the mass or specific gravity of Jupiter, is but one and a half times that of water.

We can only measure the dense cloudy envelope which surrounds the planet, and as we do not know the extent, or depth, of this envelope, its measurement will give us no clue to the specific gravity of the solid portion of the planet. At some far distant day, when the planet has lost more of its heat, the vaporous envelope will be condensed into water, and the luminous disc will doubtless measure much less than it now does in diameter. Though *we* cannot hope to detect such a change, the records of our observations may enable the astronomers of the future to discover it.

Saturn, which nearly approaches Jupiter in size, resembles him in many respects.

Like Jupiter, Saturn has a very low specific gravity, is greatly flattened at the poles, and is covered with belts, the largest and brightest of which correspond to its equator. The Sun, the source of all the heat in our system, presents some resemblance to the two largest planets. It is certainly a coincidence worth noting that the Sun has an equatorial belt 16° in breadth on which spots never appear. This corresponds to the bright equatorial belts of Jupiter and Saturn. Again, the Sun-spots are confined to two belts on either side of the Sun's equator, about 12° in breadth. As a number of minute Sun-spots are often to be seen, even at the period of minimum frequency, we may consider that we have here two dark belts situated close to the equatorial bright belt, corresponding to the two dark belts similarly situated on Jupiter and Saturn. Possibly the equatorial belt is always the brightest, and the Sun-spot belts are at all times the darkest portions of the solar disk.

There is good reason for believing that there is a periodicity in the maximum and minimum frequency of the dark belts on Jupiter, and it should be noted that we have now a maximum of dark belts on Jupiter, nearly agreeing with a maximum of spots on the Sun. Is there any relationship between these phenomena?

Considering the distance of Jupiter from the Sun, physicists have suggested that the planet shines with greater brilliancy than would be due to the solar light reflected from his surface, unless that surface had altogether exceptional reflective qualities.

Dr. Zöllner calculates that Jupiter's surface reflects ·62 of the

light which falls upon it, whereas our Moon reflects only ·17 of the light it receives. But Professor G. P. Bond assigns a far higher luminosity to Jupiter, insomuch that according to his estimates the planet actually gives out more light than it receives.

Another suggestion may be made here. Sun-spots are known to be periodical, their maximum and minimum being about eleven years apart. As Mr. Huggins some years ago observed the equatorial belt of Jupiter to be of the same ochreish yellow as it is now, there is good reason to suspect periodicity in this change.

A period of maximum of Sun-spots is now approaching. Have these two phenomena any relationship to each other? If so, why should the change in Jupiter be confined to its equator? Evidently the coloured matter, whatever it may be, is for the most part below the surface of the cloudy envelope, for besides the cumulus clouds which are constantly seen on the southern part of the belt, the whole of the surface is mottled with white markings. These I have attempted to depict in the drawing now engraved, but any such attempt can give but a slight notion of the complexity and beauty of the reality.

The white cumulus clouds on the northern (or upper side) of the yellow equatorial belt have been left behind by the rapid rotation of the planet, the surface of which at this part, travels at the rate of nearly 30,000 miles per hour.

When a change of colour is in question it might reasonably be anticipated that the spectroscope would afford us valuable information as to the nature of the change. Mr. Huggins, describing the spectrum of Jupiter in the "Philosophical Transactions of the Royal Society" for 1864, states that he has discovered several dark lines in the red portion of the spectrum, which do not correspond with any of the Fraünhofer lines in the solar spectrum. These dark lines in Jupiter's spectrum are probably due to an absorption of some of the solar rays in the planet's atmosphere, taking place both as they enter and leave the cloudy envelope.

But, supposing Jupiter to be to any appreciable extent self luminous they may be due to the presence of some elements in the planet which are not present in the Sun; or these substances may be present in the Sun, and yet not render their presence sensible by absorbtive action. If these elements are in a state of combustion, dark lines would be produced by a portion of the light they emit being absorbed by their own vapour in the atmosphere of the planet.

In the spectrum of Jupiter seen with a star telescope adapted

to my 12½-inch reflector, the *extra* dark lines referred to by Mr. Huggins are very conspicuous, and it appears to me that there are also extra dark lines, though much finer, in the green portion of the spectrum which is nearest to the yellow. Such lines may correspond to the lines due to vapour in our atmosphere, which may generally be plainly seen in this portion of the solar spectrum when the Sun is very low. I thought it barely possible that I should find a bright sodium line in the spectrum, and the yellow portion of the spectrum does seem to me to possess a disproportionate brilliancy; but I cannot speak with any confidence on this point. The spectrum is too faint to admit of very accurate observation or measurement. Contrary to what might be anticipated the spectrum of Jupiter is fainter than the spectrum of a star of the second magnitude. We know from these spectrum observations, then, that the great luminosity of Jupiter is apparent, not real, and is due to the *size* of his disc compared with the fixed stars. This may seem paradoxical, but that it is true becomes evident when we consider other instances in which increase of size produces the effect of great brilliancy.

If an observer looks at the Full Moon with a telescope of ten or twelve inches aperture, he will find the glare of light insupportable, but if he introduces a graduated diaphragm into an eye-piece of the kind contrived by Mr. Slack, he will find upon closing the moveable shutters, and thus limiting the field of view to a very small portion of the lunar surface, that he can examine details of craters without the slightest inconvenience. Yet, it is evident, that as the aperture of the telescope and the eye-piece have remained unchanged, the brightness of any part of the image cannot have been altered.

It will be remembered that the presence of a bright line would be rendered difficult of detection by its appearing on a bright continuous spectrum, formed by the reflected solar light. It may be objected that the reduction in brilliancy of the equatorial belt is incompatible with the presence of burning sodium, yet it may be that sodium vapour will not reflect the compound solar light so well as the bright cloud belt when it consists of the vapour of water only.

Bright lines on a continuous spectrum, as discovered by Janssen and Lockyer in the chromosphere, or solar envelope, are due to the presence of gases in a state of ignition.

Sodium in a similar state, if the atmosphere of the planet has become charged with its vapour, might produce only an intensifica-

tion of the double D Fraünhofer lines. Such an appearance may easily escape recognition.

I am having an exceedingly powerful spectroscope constructed, in which a novel method of micrometic measurement will be adopted, specially adapted for dealing with very faint objects. Should any more positive results be obtained by using this apparatus, an account of them will appear in this journal.

Meanwhile, the planet should be closely watched. Mr. Slack detected the change in the colour of the belt probably as early last year as myself, using a reflector of only six inches aperture.

As it will be a matter of great interest to determine when the colour disappears from the equatorial belt of Jupiter, the planet should be watched by those who have a good western view, so long as he remains in our skies. By employing the Astronomer Royal's admirably ingenious eye-piece for correcting the prismatic colours produced by atmospheric dispersion, useful observations may be made until the planet is within a few degrees of the horizon. By diligent observation, even with telescopes of moderate power, much knowledge may yet be gained of the planet.

In an admirable article which recently appeared in the "Daily News," the following remark occurs :—

"One of the most interesting features of modern astronomical progress is, the attention which observers now direct to phenomena which were thought, not so many years ago, comparatively insignificant. They begin to recognise that there is scarcely a single celestial phenomenon which has not, besides its direct significance a meaning that lies, so to speak, beneath the surface."

Observations of the stars, their distance, magnitude, and variability, necessitate the use of costly apparatus that requires considerable skill on the part of the observer; but observations and careful drawings of the planets, made persistently for a series of years, as in the case of Schwabe's thirty years' observations of Sun-spots—may enable a thoughtful observer to discover some unsuspected facts which will throw a light on the condition of these *other worlds.*

ON POISONS.

BY F. S. BARFF, M.A.,
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No. I.

It is difficult, if not impossible, to define what a poison is. There are substances which are perfectly wholesome when taken in moderate quantities, which, however, may cause death when taken in excess, and the same substance may be taken in the same proportion by two people, in one, it produces no effect, but in the other, considerable inconvenience and perhaps very serious results. Even among what are generally recognised as poisons, some cause death in small, others only in large doses. If a person drink largely of cold water, when the body is over-heated, effects may be produced which resemble poisoning, and even death may ensue, but water is not therefore a poison, for the same quantity, taken under other circumstances, would prove harmless. Again, substances which are in common use, such as table salt, sulphate of magnesia, have been known to cause death, when the quantity taken has been excessive. Dr. Christison relates a case, which occurred in London, of a man who took a pound of salt in a pint of ale, and died within twenty-four hours. Also another of a girl who died, in consequence of taking half a pound of salt as a vermifuge. The same authority mentions the death of a child, who took, as medicine, two ounces of Epsom salts, and died within an hour. The circumstances in this case were investigated judicially, and it was proved that the substance taken was pure sulphate of magnesia, which was administered by the father, who was exceedingly fond of the child. It appears, then, that the state of the person taking a substance, or the quantity in which it is administered, may very seriously influence the effects produced. That this is the case will be more clearly manifest, after some of those bodies, which are admitted to be poisons, have been treated of. It is generally said that a poison is a substance which, when taken in *small* quantities, has a tendency to cause death. It is true that many poisons taken in very small quantities, destroy life, but then there are others, usually classed among poisons, which only do so when taken in tolerably large doses. A person may die from taking a quarter of a grain of strychnia, but it would

require nearly half an ounce of oxalic acid to produce the same effect. Neither the smallness nor the largeness of the dose then constitutes a substance a poison, but the action which it has on the person taking it; if that action be fatal, the poison is termed *deadly*, a word which is used in indictments, and which has often given rise to discussion as to whether a substance was a poison or not. For instance, if a person, knowing that two ounces of Epsom salts had caused death, destroyed the life of another by administering it to him, it could not be said that Epsom salts was a deadly poison, for it is ordinarily a wholesome medicine. A case occurred at the assizes at Norfolk in 1836, in which two persons were capitally indicted for having feloniously caused to be administered to the prosecutor, a certain "*deadly poison*," called sulphate of copper, with intent to murder him. The counsel in defence argued that sulphate of copper was not a deadly poison. In this case the two medical witnesses, who gave evidence, differed in opinion, and the result was, that the prisoners were acquitted. It has, however, been decided by Mr. Justice Erle, that such terms ought to be omitted. We may say generally, a poison is a substance which interferes, more or less, with the proper action of some of the healthy tissues of the body; and in proportion as the derangement produced is greater or less, so the poison is more or less dangerous. And this action is often of two kinds, local and secondary.

By the term "tissues of the body" is meant the blood, nerves, muscular fibre, membranes, etc., and not necessarily organs which are composed of several of them. There is a membrane lining the stomach, and the whole of the alimentary canal, which is called a mucous membrane. It occurs in other parts of the body,—in the mouth, the nose, and lining the eyelids. Certain poisons specially affect this membrane, although their action is not entirely confined to it. Others specially affect the blood, and of this kind are some poisonous gases; and others, such as opium, prussic acid, and the narcotic poisons, act directly on the brain and nervous system. Many poisons are used medicinally.

The peculiar effect on the system which strychnia produces is taken advantage of in certain diseases, and as a remedy it is found to be very useful in affections of the intestines, when their contractile power is weak, as well as in cases where there is a want of tone in the muscles, one of the effects of strychnia, when taken in poisonous doses, being to produce too great muscular activity. When, then, a part of the body is not performing its functions fully, a substance, which in its healthy condition would by excessive

action cause its derangement, may be usefully employed to stimulate it to healthy activity. If a person swallow strong hydric-sulphate (oil of vitriol), its first action is to destroy the surfaces with which it comes in contact, and this it does by chemical action, in the same way in which it decomposes sugar and some other organic bodies, by burning them; that is, by uniting with and abstracting from them some of the elements which enter into their composition. This action of hydric-sulphate is *local*, and if it reach the stomach it will destroy its coats in those places where it comes in contact with it, so hindering it from performing its functions. But then there is also another action which is induced by it, inflammation is set up, ulceration occurs, and it produces as secondary or remote effects, sometimes delirium, epilepsy, and lock-jaw, the person often dying in a state of collapse, in convulsions, and sometimes from suffocation. Now, all these effects may be produced by natural diseases. These two poisons, strychnia and hydric-sulphate, are types of two classes. The strychnia sets up no *local* mischief, whereas the oil of vitriol does; and it is owing to this local action that it acts as a poison, though the *immediate* cause of death is its secondary or remote effect.

From these two examples of different poisons it will be seen how difficult it is to frame a definition of what a poison is. In the first case the action is like that which we are accustomed to attribute to poisons; in the latter similar effects might be produced by what are called mechanical means.

Dr. Guy says, "A poison is any substance which, when applied to the body externally, or in any way introduced into the system, without acting mechanically, but by its own *inherent* qualities, is capable of destroying life." This definition is perhaps as good as any which has yet been given, and is useful for medico-legal purposes; but as a scientific statement it seems defective, as the word *inherent* can hardly be said to apply to the action of oil of vitriol, which does no more than may be produced by a mechanical injury; in fact, in cases where it has been swallowed suddenly, almost instantaneous death has been caused by suffocation, just as would be produced by getting a piece of meat into the windpipe. Nor is it much more easy to explain the action of poisons. Of some, however, the effects are more manifest than of others.

Poisons are usually divided into three classes according to their action on the body. This seems the best system of classification to adopt. If their chemical properties were taken as a basis of a

classification, we should have bodies ranged in different groups, which have a similar action on the animal organs; and as we are not considering them primarily from a chemical point of view, but from a toxicological, it seems but rational that we should arrange them according to their tonic effects. Therefore toxicologists usually divide them into three classes. First, irritants—metallic, non-metallic, vegetable, and animal; secondly, narcotics, which are all organic poisons—the most important poisonous gases, carbonic acid, carbonic oxide, sulphuretted hydrogen, and coal gas, are, from their effects, classed with narcotics—and, thirdly, narcotico-irritants, which are also organic.

The irritants, as their name implies, cause irritation or inflammation. Their action is at first local; but many of them produce remote effects. The strong acids, such as hydric-chloride,* hydric-nitrate, and hydric-sulphate, belong to this class; also the alkalies, soda and potash, together with certain of their compounds, and some lime and baryta salts. The strong acids, the caustic alkalies, and their carbonates, and some of the metallic poisons, destroy the lining membrane of the mouth, throat, stomach, and intestines, as well as any adjacent structures with which they may come in contact. They corrode them, and hence they are termed corrosives. Many of these irritant poisons are taken up by the blood, which becomes poisoned, and through it they irritate the nervous system. Arsenic, a well-known poison of this class, acts locally when taken into the stomach, and also remotely on the stomach, through the blood by absorption, when it is placed under the skin, or applied to an open wound.

In the case of a Guinea-pig which was poisoned by a grain of white arsenic injected under the skin, the stomach was found to be highly inflamed; and, moreover, the action of the poison was more rapid than when the same quantity was administered by the mouth to a similar animal, under exactly similar circumstances. As arsenic is a good example of an irritant poison, and is one which is too frequently employed by the poisoner or suicide, it will be well to carefully consider its action, as it is a good type of the class to which it belongs. Arsenic, or arsenious acid, is formed by the union of the metal arsenic, or arsenicum, with oxygen gas, in the proportion by weight of 150 parts of arsenicum to 48 parts of oxygen. It is usually met with as a white heavy powder, almost tasteless; it is, however, said to be sweetish. It is also found in flat solid

* Common names, muriatic or hydrochloric acid, aquafortis or nitric acid, oil of vitriol or sulphuric acid.

masses which are formed by sublimation; these lumps are at first almost transparent, but after a time become opaque, and then have the appearance of white porcelain, but more transparent in some parts than in others. Arsenious acid is only slighly soluble in cold water. The two varieties differ in degrees of solubility, the transparent being said to be the more soluble. Boiling water dissolves about twelve per cent of the powder. Organic matter mixed with water hinders its solution, and this fact has important bearing upon its poisonous action, for if less be dissolved, less will be able to pass into the system, as it is only in the form of a solution that it can pass into the blood. Arsenic has so slight a taste that it may be swallowed without the knowledge of the person taking it; hence it is the most common poison employed for the commission of murder. In 1851, an act was passed to limit the sale of arsenic, and the number of deaths caused by it consequently diminished. In the years 1837 and 1838, 543 deaths occurred from poison, and out of them 185 were caused by arsenic. In the years from 1852 to 1856, 27 persons only died from taking it *each* year out of 268 who died by poison. In 1837 and 1838, the proportion was one in three, and in the later years one in ten.* Since the Act of Parliament passed in 1851, arsenic cannot be sold in small quantities, unless it be mixed with some colouring matter, such as soot, indigo, or ultramarine, and it is only sold in large quantities to persons who are well known to the seller. Arsenic, or, as it is commonly called, white arsenic, is not the only form in which this poison occurs in commerce. There are certain pigments which contain arsenicum. The paint called king's yellow, well-known as the opaque yellow of the water-colour box, is a mixture of arsenious sulphide and arsenic, emerald green, Scheele's green, Schweinfurt green, are chemical compounds of copper and metallic arsenic. They are generally employed to produce the brilliant greens in room papers. There is also a blackish powder called "fly-poison," which is formed when the metal arsenic is exposed to moist air, it is most probably a mixture of the metal with arsenious acid. Arsenic is also used as a medicine, and is generally united with an alkali, as in liquor arsenicalis or Fowler's solution, which contains arsenite and carbonate of potash. There are four grains of arsenious acid in the fluid ounce. It is dissolved in hydric-chloride in liquor arsenici hydrochloricus. Arseniate of soda, and arseniate of iron, are also used in medicine. The first of these preparations is, however, the most important. The compound of arsenic and hydrogen in gaseous bodies is highly

* These numbers are taken from Dr. Guy's "Forensic Medicine."

poisonous; it is commonly called arseniuretted hydrogen, it is found wherever arsenic is present in a mixture from which hydrogen is being liberated. Arsenic is a constant impurity of common oil of vitriol, which is generally used with zinc for the evolution of hydrogen gas. If much arsenic be present in the oil of vitriol it will all pass off combined with hydrogen, and has in some cases proved fatal. The higher oxide, called arsenic acid, in which the metal and oxygen are combined in the proportion of 150 parts of arsenic to 80 parts of oxygen, is far more soluble in water than common arsenic; but Dr. Taylor says that he never heard of its being used as a poison. Some have doubted whether the sulphides of arsenic have poisonous properties. There are three sulphides, two of which are found native. They are the red, which is called realgar; the yellow, which is called orpiment; and the penta sulphide, which is only obtained artificially. A sulphide, arsenious sulphide which has the same chemical composition as orpiment, containing 150 parts of arsenicum to 90 parts of sulphur, is obtained artificially by the action of sulphuretted hydrogen on an acid solution of arsenic.

Native sulphides are less poisonous than those which are artificially prepared; and the idea that they are not poisonous at all was strengthened by the experiments of Hoffman and Regnault, who administered them to dogs, and other animals, without producing any derangement. But the poisoning of Mrs. Smith, of Bristol, recorded in Beck's "Medical Jurisprudence," clearly establishes their poisonous character. This lady, shortly after coming to lodge with a Mrs. Burdock, caught cold, and took some gruel, which her landlady gave her. In a short time she was taken very ill, and suffered from violent pain. No medical assistance was summoned, and she died in about an hour. Her burial was private. This, and other causes, excited suspicion, and investigations were made which led to the discovery of poison in her body, and this poison was sulphide of arsenic. The examination was conducted by Mr. Herapath, of Bristol, who clearly proved the presence of both sulphur and arsenic, and it was subsequently discovered that Mrs. Burdock had tried to obtain arsenic from a druggist, but he, not having any in stock, gave her the sulphide instead. The knowledge of the poisonous properties of this substance should make persons careful in the use of any compounds which contain them, such as colours, which may fall into the hands of children, or be incautiously applied to the lips or tongue, either in the cake, or as is more commonly the case, by means of the brush. A considerable amount of alarm was caused some time ago by accounts of serious

disorders being produced by green room papers. The author had several samples of paper sent him for analysis, in all of which arsenic was found. By his advice the papers were allowed to remain on the walls, and in order to prevent any escape of arsenic into the rooms, they were sized over, so as to completely prevent the colour from coming off. Cheap room papers, where the colours are not properly fixed, are no doubt bad, because small particles containing arsenic can be rubbed off, and these floating about in the air in a state of very fine division may be inhaled, or persons may very easily get some of the powder on their hands, and incautiously convey it to their mouths. Dr. Basedon asserts that if Scheele's green be used in painting apartments, it may give rise to a dangerous evolution of arseniuretted hydrogen gas, under the influence of moisture. It requires experimental proof to demonstrate the truth of this assertion. It is not at all probable that a body of its composition would be decomposed in this way. Moreover, the oil used with the paint would prevent the action of water upon it. The compounds of arsenic, used as pigments, are not volatile except at a very much higher temperature than that to which they could, under the circumstances, be exposed, so that no fear need be felt in employing them. When arsenic is taken internally, by the mouth, its first action is to produce, after a short time, a burning sensation in the stomach and vomiting; there is also a painful sensation of constriction about the throat, accompanied by great thirst. The heart beats violently, the pulse is quick, there are cramps in the legs, and twitchings in the muscles. The eyes smart, and there is pain in the head. There is great tenderness over the whole abdomen. If the dose taken be sufficient to destroy life quickly, the person generally dies in a state of coma; that is, the nervous system is affected, and ceases to influence the movements of the muscles, so that respiration and the circulation of the blood are impeded. The mind, in very many cases, remains perfectly clear throughout the attack. If the action of the poison be slow, febrile symptoms come on, and after a time death occurs, accompanied by convulsions. Or if the dose taken be hardly sufficient to cause death, or if from treatment its effects have been mitigated, still it often leaves behind an impaired digestion, and other disarrangements of the system, which may last through life. The action of arsenic, however, seems to be very different in different persons; in some it acts very rapidly, in others more slowly. The first symptoms generally come on in about an hour after the poison has been taken, but a case is recorded in which they began in fifteen minutes,

another in which they occurred in ten minutes. Then they may be delayed as long as two hours. A case is given in "Beck's Medical Jurisprudence," which was communicated by Mr. Macaulay, of Leicester, where an individual took the poison at eight in the evening, went to bed at half-past nine, and slept till eleven, when he woke with slight pain in the stomach, vomiting, and cold sweats. In this case the quantity taken was seven drachms, and death took place in nine hours.

Our space will not admit of our pursuing this part of the subject further, or of *citing* more of the many instances on record of the action of this deadly poison. What quantity of arsenic is necessary to cause death? Dr. Taylor says, the smallest fatal dose of arsenic in solution is stated to have been four grains and a half; it was taken by a child who died in four hours and a half. Dr. Guy mentions a case in which two and a half grains proved fatal to a strong healthy girl of nineteen; there are cases on record in which two grains have given rise to very alarming symptoms; and there are also others, where persons have recovered after taking half an ounce, or even an ounce of white arsenic. No doubt the conditions under which it is taken, either tend to promote or retard its effects. When taken fasting and in solution it acts more perfectly and rapidly; when taken on a full stomach it is not dissolved, and may pass away without causing much inconvenience, even when taken in tolerably large doses. The usual treatment adopted, is to empty the stomach as quickly as possible by means of emetics, such as large draughts of warm water, or warm salt and water; tickling the throat with a feather also promotes this action. If ipecacuanha is at hand it should be given, the substance known as tartar emetic should not be given, for reasons which will be explained when antimony is treated of. In all cases of poisoning, medical assistance should be obtained at once, but in the mean time the remedies already mentioned may be used—there are certain substances which are regarded as antidotes, though there is no very strong evidence to prove that they are efficient—the hydrated sesquioxide of iron, which can be readily prepared by adding ammonia to a solution of the sesquichloride or sesquisulphate, is supposed to form a chemical compound with arsenious acid, which is insoluble and innoxious. Freshly precipitated magnesia obtained by adding a solution of potash to the sulphate, or calcined-magnesia have been given as antidotes, these two latter substances can be easily obtained and might be given *immediately*, before medical aid could be obtained, if it were known that the poison taken was arsenic.

Before concluding these remarks on the action of arsenic, it seems necessary to mention that there is a form in which arsenic enters into articles of commerce, where it may produce very unpleasant, if not serious consequences. Candles of a particular kind contain arsenic, and when they burn they must give off fumes of the oxide which is very volatile, and may be easily inhaled. Arsenious acid has the property of preserving animal matter from decay for a considerable length of time. It is often used for this purpose when the substances to be preserved are not required for use as articles of food. It has been found that the bodies of persons poisoned by arsenic have for a long time remained uncorrupted. An individual died at Bourg, in France, in 1822, and was disinterred in 1829. The body was entire, the internal parts, however, had suffered from decay. They were submitted to analysis, and arsenic was found. The body of a person was disinterred three years after burial, it was in a state of remarkable preservation; on being opened, there were no noxious matters discovered, but on further examination, arsenic was proved to have been the cause of death.

In poisoning by arsenic the symptoms are generally so well marked, and are so combined, that it is not easy to confound it with or mistake it for natural disease, their occurrence shortly after taking food, the difficulty of swallowing, the pains which affect different organs of the body, and the nervous symptoms, all tend to show that the attack from which the person is suffering does not arise from natural causes. We have now to consider perhaps the most important branch of our subject, the methods used in detecting poisons. First it is necessary to discover, if possible, whether a substance, of which a person has partaken, is a poison or not. Suppose the case of a man suddenly attacked with pain and showing symptoms which lead to the suspicion that he has been poisoned, one would naturally inquire what food he had taken last, and if any of the remains of it could be found, they should be submitted at once to such tests as might prove whether they contained a poison or not. The symptoms would to a great extent guide the inquirer as to what poison should be first sought for, and if its nature could be detected, it would regulate the method of treatment to be adopted. Hence it is that the study of toxicology *practically* is so important to the medical practitioner.

After death, if it is suspected that poison has been administered, an analysis of various parts of the body is ordered by the coroner to be made, and this work is generally entrusted to a professed toxicologist, and rightly so, because the knowledge required to conduct

such examinations can only be acquired by great practical experience. But the testing of simple substances without complications is not difficult for one who has a tolerable practical knowledge of chemistry. It will, perhaps, be better to describe the method employed in testing for arsenic, and then to show how it may be applied in various cases. In treating of the different well-known poisons, it seems advisable to give at the conclusion of each the various chemical reactions by which it may be identified. The metal arsenic, or arsenicum (which in the metallic state is not poisonous, as has been proved by the experiments of Regnault), is of a grey colour; it has a brilliant metallic appearance, when in mass it easily breaks up into small particles; when sublimed by heat, if the deposit be received on glass, it is generally bright and causes the glass to have somewhat the appearance of a mirror, only that it looks darker than an ordinary one. Its vapour has a peculiar smell, which has been compared to that of garlic, and is termed alliacious. Such a description would hardly enable a person smelling it for the first time to identify it. It is impossible to convey a definite idea of an odour in words, it must be smelt to be appreciated. Arsenicum oxidizes in moist air slowly, and rapidly when heated in air; its vapour, therefore, is poisonous if it escape into air; and in the solid state it becomes poisonous also, if the air be moist. In all poisoning cases, when arsenic is sought for, it should be produced in the metallic state. It has already been stated that the sulphide of arsenic is a yellow solid, and that it is obtained by causing sulphuretted hydrogen (a gas formed by the union of sulphur with hydrogen) to act upon a solution of arsenic, and that this solution should be acid.

In examining a solution, the first step is to render it acid with hydric-chloride,* and then to saturate it with sulphuretted hydrogen, that is, pass in the gas till no further precipitate is formed. In this way the arsenic is all got out of the liquid; and one proof that it is arsenic, is that the precipitate is yellow. No great dependence, however, can be placed on this, as circumstances sometimes arise which considerably modifiy the colour of precipitates. The next step is to carefully dry a portion of the precipitate, and having mixed it with potassic cyanide and sodic carbonate, to heat it carefully in a long thin glass tube, called a reduction tube. In a short time a metallic ring will be formed in the tube just above the mixture which has been heated, and this ring is one of metallic arsenic, the changes which have taken place are too complicated

* Muriatic or hydrochloric acid.

to be explained here. Another part of the sulphide is to be treated with ammonic sulphide which will dissolve it, if it be arsenious sulphide. Again a part should be treated with ammonic carbonate which will also dissolve it. The use of these reactions will be better understood when we consider the examination for other metallic poisons. The remainder of the precipitate should be gently heated with a mixture of hydric-chloride and hydric-nitrate, and evaporated nearly to dryness; a little additional hydric-chloride and distilled water must be added, and the solution is to be used in the manner to be described presently. In speaking of arseniuretted hydrogen, it was stated, that, when arsenic, or a salt of arsenic is placed in a vessel where hydrogen is being generated, the arsenic unites with the hydrogen, forming arseniuretted hydrogen. If now the liquid, obtained by heating the sulphide with hydric-nitrate, and hydric-chloride, be poured into a suitable apparatus, where hydrogen is being evolved, then arseniuretted hydrogen will pass off, and if led through a glass tube with a small orifice at the end, where it escapes, it can be lighted, and will burn with a peculiar lurid flame, which is highly characteristic. When a white plate is held in the flame from a common gas burner, a black deposit is formed; this is because the gas is partially decomposed into carbon and hydrogen; its constituents, the hydrogen—burns, but some of the carbon is deposited as soot. If a piece of cold porcelain be held in the burning arseniuretted hydrogen, a black spot will be formed on it, because the arsenic, like the carbon in the coal gas, is deposited.

A further proof that it is arsenic, is obtained by treating the black spot with a solution, made by dissolving chloride of lime, (common bleaching powder) in water, when it will disappear completely, through its solution in the liquid. If the tube, through which the arseniuretted hydrogen is passing, be made red hot in one particular place, a short distance from that spot, and nearer the end of the tube where the gas escapes, a dark metallic deposit will be found in the tube in the form of a ring, and this is a deposit of metallic arsenic produced by the decomposition, by heat, of the arseniuretted hydrogen. When arseniuretted hydrogen gas is led into a solution of argentic nitrate (nitrate of silver), a black precipitate is formed, and arsenious acid is in the solution. If the liquid now be filtered off, it will contain arsenious acid, argentic nitrate, and hydric nitrate, and if it be made neutral with very dilute ammonia, a precipitate of yellow arsenite of silver, will be thrown down. This is a most distinctive test, and one on which

great reliance can be placed. It is clear then that if all the reactions, above described, be produced by a given substance, no doubt whatever can be entertained but that it is arsenic. All these tests, and even more than these, should be performed before a toxicologist gives his opinion that the substance submitted to him for examination contains arsenic. The test in which arseniuretted hydrogen is employed, is known by the name of Marsh's test. Reinsch's test, which is well-known, is founded on the principle that a metal, which is chemically more active than another, is able to displace it from its combinations. Copper is chemically more active than arsenic. When then, a solution containing arsenic, after having been acidulated with about one-fourth of its bulk of hydric-chloride, is boiled with a piece of bright copper wire gauze, in a short time a deposit is thrown down on the copper, which is more or less metallic-looking according to the quantity of the arsenic present in the solution. Other metals besides arsenic are precipitated on copper under the same circumstances; therefore the deposit has to be submitted to further examination. The piece of copper with the deposit on it should be carefully dried in blotting paper, and then placed in a long narrow glass tube open at both ends, the tube should be made red hot at the place where the copper is, and air passing through the tube will meet with the metal arsenic (which being volatile) will be driven by heat from the copper, and the result will be the oxidation of the arsenic, for it will be remembered that arsenic is readily oxidized when heated in air, or free oxygen; the substance formed will be arsenious acid, which will be deposited on the inside of the tube in small bright colourless crystals. If the piece of tube containing these crystals be cut off, and boiled in a small quantity of distilled water, a solution of arsenious acid will be obtained, which can be submitted to some of the tests, which have been before described. Reinsch's test, however, is not, on the whole, satisfactory, and should never be relied on alone. In a future article, the treatment of arsenic and other metallic poisons in organic mixtures will be described, as also the method of testing for poisons, when they are found in powder or in the dry state.

THE DIVINING-ROD.

AN HISTORICAL SKETCH.

BY HENRY WHITE, PH.D.

WHEN a boy at school I used to spend my summer holidays with an uncle, a farmer, on the borders of Hampshire and Wiltshire, a far more agreeable mode of spending the time than conjugating verbs in μι, or hearing the Pius Æneas "infandum renovare laborem" to Queen Dido. One day I saw a little group of people on the other side of the valley, walking apparently in procession. At once I scampered off through brake and briar to learn what it meant; but all I can remember was a man walking about two yards ahead of the others, holding a forked hazel stick in his hand, and dodging about in a very eccentric manner. I was told afterwards that he was old Jem Brown, ex-poacher, etc., who lived "down street," and that he was "water seeking." This was about the year 1826.

About six years later I became intimate with a family in Worcestershire, one of the members of which was said to possess this "water-finding" faculty. I heard of instances in which the young lady's skill had been tried, but never witnessed an experiment.

These are the latest examples I know, of the long-continued belief in the virtues of the divining-rod. These virtues may be (and probably are) imaginary, the adepts may be cunning tricksters, but every now and then some new witness comes forward with fresh instances, that almost shake our scepticism. In the "American Journal of Science" (vol. iii., 1821, pp. 102-104), is a letter from the Rev. Ralph Emerson, containing an account of several "well-authenticated facts" on the use of "mining-rods," as they were called. He relates how an old schoolfellow (Rev. Mr. Steele of Blomfield, N.Y.), had called upon him a few weeks before, and in the course of conversation had mentioned that the rods would "work" in his hands. He was put to the proof. A peach-twig was procured which bent, and often "withed" down from an elevation of 45° to a perpendicular over certain spots, and when these had been passed, it assumed its former elevation. Mr. Steele succeeded in tracing a subterraneous current of water up to the spring, marking out the line, crossing back and forth, just as a dog seeks out his master's track. "The result, however inexplicable, removed all my doubts," says Mr. Emerson, who continues his letter by describing what he had seen in the S.E. part of New

Hampshire, "where these rods have been in practical use for a year or two past, in fixing on the best places for wells." He did not witness any experiments, but was told of several, particularly of a farmer who was advised to sink a well at a particular spot. The latter wishing to spare a favourite tree, dug a little on one side of the spot indicated, but could not reach water. He complained to the water-seeker, who stuck to his text, and the farmer rooting up the tree, found water at the specified depth. The editor (Mr. Benjamin Silliman) expresses his scepticism, adding, that he had "never *seen* any experiments;" but that when "attested" by such authority as that of the Rev. Mr. Emerson, "they will ever command our ready attention."

In the first volume of the "Archiv der Medizin" (Aarau, 1816, p. 56), there is an account of one Catherine Beutler, who was travelling through Switzerland under the care of Captain Hippenmeyer, who (as Oken informs us in his Journal, "Isis," 1818, col. 140) was a nephew of the great Vienna banker, of that name, and "consequently not a person likely to speculate with her abilities." She pointed out two spots where water would be found, and it really was found in both instances. When she was over places where minerals are situated, she became very pale, was attacked with spasms, and appeared unable to breathe, while a heavy perspiration broke out on her face in large drops. All the symptoms vanished as soon as she moved to a place beneath which there were no minerals. As soon as the symptoms appeared, she took a forked divining-rod made of whalebone, which she grasped firmly; the further end moving towards her until she had reached the boundary of the hidden strata. Several tests made unexpectedly, and in different places, confirmed (if we may credit the "Archiv") the correctness of the woman's power to find both water and minerals. This case attracted the attention of Oken, who treated it seriously, believing however, that the known facts were as yet insufficient to guarantee her good faith. In Alsace there existed a Rhabdomantic Society, who believed so firmly in Catherine Beutler's powers, that they petitioned the king of Wurtemburg to employ her services for the discovery of coal, etc., in his states. The king consented, but whether she was successful or not I cannot say, as the experiment had not been made when Oken wrote. Catherine is described as being a very robust healthy woman, able to work hard, and not at all nervous. She also professed to be able to cure diseases by certain movements of her hand and fingers. "Those may believe this who likes," says Oken, "I will say nothing about it." Gilbert

mentions Catherine Beutler's case (Journal, vol. lx., 1819, p. 323), and expresses his sorrow that "a real *physiker* had not watched the experiments. Zschokke, who drew up the reports, and believes in her powers, is an honest historian, but not *physiker* enough to be able to judge." Pryce in his "Mineralogia Cornubiensis," gives several instances in which lodes were discovered by means of the rod; few of them, however, turned out profitable, the rod dipping equally to a rich as to a poor lode. A person assured me (says Mr. W. Phillips), that by the accidental use of the rod, in a place where he did not expect that it would have been acted upon, namely, in his own shop—he discovered a lode which is now working under the town of Redruth. *

All these examples belong to the present century. Let us now go back a little farther, and trace the history of the rod—not, as the Jesuit Ménestrier does, from Jacob's "rods of green poplar, and of the hazel and chesnut tree," nor from Aaron's rod, which worked such wonders among the Egyptians—but from the time of Dame Martine de Bertereau, Baroness of Beausoleil, who published a little work in 1632, in which is contained a list of one hundred and fifty mines discovered by herself and her husband, a distinguished engineer. Among the apparatus employed we find enumerated seven metallic rods, known by the miners of the Tyrol as the *verga lucente, verga cadente o jocosa, verga saltante, verga battante, verga trepidante, verga cadente o inferiore, e verga obvia.* The Baron of Beausoliel and his wife must have been experienced mineralogists, for they had examined almost all the mines in Europe, and had even crossed the ocean to explore the mineral treasures of the New World. Their geological knowledge had evidently served them in good stead; and we may well believe that in the use of the sympathetic rod, and other fantastic instruments, they conformed to the hermeneutic fancies of the age, in order to give a supernatural appearance to the results of their natural skill. It was a great mistake, for it led to their being accused of unlawful practices, and to their imprisonment at Vincennes, where they both died.

The news of the magical powers contained in the divining-rod soon spread through France, and thence to other countries, the "sourciers," or "sourcers" (as we may call them), being very numerous in Dauphiny about 1640. Father Kircher, the Jesuit, denying that the rod had any power to discover hidden metals, acknowledged that it had a tendency to move towards subterranean

* "Philosophical Magazine," ed. by A. Tilloch, xiii., 1802, p. 325.

waters. "Which I would not say," he adds, "if I had not tried it." (*Quod non dicerem nisi a me sumpto id verum cognovissem.*)

What did most to spread the reputation of the divining-rod, and eventually to discredit it utterly for a season, was the use made of it by Jacques Aymar, in 1692. In July of that year the keeper of a wine-shop in Lyons and his wife were murdered in their cellar. The murderer had left behind him a bottle, wrapped in straw, and a blood-stained bill-hook. The officers of justice were at their wit's end—sometimes not a very long journey even in our days—until a neighbour advised them to apply to Aymar, who had manifested a singular aptitude in hunting down criminals.

Jacques Aymar was a native of St. Marcellin, in Dauphiny, and in 1688 had been summoned to Grenoble to discover the perpetrators of a certain theft. With the help of his wand, he picked out two persons from a number of prisoners in the city gaol. At first they stoutly maintained their innocence, but eventually confessed and named the receivers of the stolen goods. These were farmers, who denied all knowledge of the matter; but the divining-rod gave the lie to their assertions by conducting Aymar to an artfully-contrived hiding-place, where the plunder was found.

On another occasion he accidentally discovered a murder. He was out one day water-seeking, when the rod became violently agitated. A well was sunk, but instead of water, the diggers came upon a barrel containing a dead body, with a cord still remaining on the neck. It was that of a woman who had been missing for about four months. The rod conducted Aymar to the house where she used to live: it was motionless until he arrived in the presence of the woman's husband, when it became violently agitated. The man confessed his guilt by running away. We must be cautious, however, in accepting the man's flight as a proof of his guilt, rather than of his fear. In those days a person accused of a crime in France had little chance of proving his innocence. A witty Frenchman once said that if he were accused of stealing the towers of Notre Dame, he should at once run away.

Such was the reputation Jacques Aymar enjoyed in Dauphiny when he was summoned to Lyons, to enquire into the double murder at the wine-shop. Holding a rod in his hand, he went into the cellar. The rod was motionless until it was over the spot where the man's body had lain, when it became violently agitated. He himself grew excited, and his pulse beat with feverish rapidity. This emotion was still greater when he reached the place where the

woman's corpse had been found. He traced the assassins—they were three—step by step, through the city and down the Rhone, to the camp at Sablon. He was too late; they had gone. He continued his course down the river to Beaucaire, which was at that time very crowded by visitors to the annual fair. His rod led him to the prison, and then out of fourteen or fifteen persons he selected one who had just been brought in, charged with some petty theft committed in the fair. The other two escaped, but the third confessed his crime and was executed.* Del Rio, who, in his "Disquisitio Magica," bk. 3, had recommended the use of the hazel-rod to discover thieves, never contemplated its being employed to track down murderers.

The Prince of Condé (Henri-Jules, son of the great Condé) invited Aymar to Paris, where he became quite a lion, and many opportunities were offered him of showing his skill; but he failed so frequently that he lost all credit, and returned in disgrace to his native province of Dauphiny. Here he was still in good odour, and was employed by Montrevel and Baville to hunt down the Protestants of the Cevennes.

Jacques Aymar had many successors in Dauphiny, the most famous of them being Bartholomew Bletton, who became the most famous hydroscopist of the age. He could discover water without the aid of the wand, which he used merely for the information of the spectators. He came to Paris where his pretentions were very closely investigated, the celebrated Lalande publishing in the "Journal de Physique" for August, 1782,† an account of the test experiments. Lalande says that Bletton made the rods move by an imperceptible pressure of the fingers. This may be true, but no attempt seems to have been made to solve the previous questions—whether hidden sources of water had really been discovered by Bletton, and whether such discovery might not be owing to some extraordinary sensibility, which would make the movement of the fingers quite involuntary. The Parisian physicists had made up their minds that Bletton was an impostor, and treated him accordingly. "I have written against Parangue (another hydroscopist)," said one, "and belong to three Academies, and you want me to believe such stuff." That is hardly the spirit of a philosopher —of a searcher after truth. A very different spirit dictated the

* A full account of this singular case will be found in the Abbé Vallemont's "Physique Occulte," vol. i., pp. 27—49. This book was put in the "Index" by the Roman Inquisition (1701), which some may consioer a strong recommendation.

† "Copie du Procès-verbal," etc., tom. x., part 2, 1782, p. 58.

reply of Dr. Treviranus to the inquiries put to him by Coleridge, as to the reality of certain magnetic phenomena which that distinguished *savant* was reported to have witnessed: "I have seen what I would not have believed on your testimony, and what I cannot, therefore, expect you to believe on mine."

Dr. Thouvenel, who took Bletton in hand, says that in upwards of 800 experiments made under his eyes in Lorraine, water was found, the operator being in many instances blindfolded. In reading the accounts of the Parisian inquiry, we cannot but feel that the believers were ultra-credulous, the sceptics equally incredulous. If the latter made too much of Bletton's failures, the others treated too loudly of his successes. In 1783, Dr. Thouvenel was commissioned by Louis XVI. to make a chemical examination of the mineral and medicinal waters of France. Bletton went with him and assisted him greatly in discovering the direction of the springs and tracing them to their source. During this expedition he found some coal beds, and was employed by the School of Mines to seek for coal in the neighbourhood of Paris. Bletton is still remembered in Dauphiny as one of its greatest benefactors.

Jean Jacques Parangue was a very different man from Bletton, though, like him, he began to exercise his hydroscopic faculty when a child. One day, while sitting at the fireside, he suddenly cried out "I am lost—I shall be drowned," and jumped up to escape from the fancied danger. He was subject to the same strange panics while in the field tending cattle. But his most singular faculty was the power of seeing through things. "The earth became transparent as crystal," says an admirer; "more transparent indeed, for he could not see water through glass, though he could see it through rocks or stone walls."

The pretended faculties of Parangue were smartly satirized in a little pamphlet (noticed by Figuier) giving an account by Lord Norton of one Miss Jenny Leslie, a young woman of nineteen, who could not only see through rocks and stones, but could discern what was going on within the human body. The motions of the heart and lungs, the passage of the blood, were clear as daylight to her. She could see all the convolutions of the brain, and the soul snugly seated within the pineal gland. She could read very distinctly the thoughts as they arose in the mind, and could tell you your plans before you knew them yourself. The writer proposed to marry this English clairvoyante to the hydroscopist Parangue, in the hope of perpetuating "an introscopic faculty," which would go on increasing, until the human race had arrived at a state of perfecti-

bility. The joke falls rather flat now, but it raised a good laugh at the time of its appearance.

One of the last of these remarkable "sourciers" was Campetti, a young Italian, who performed a number of experiments at Munich in 1806 in the presence of Shelling and Franz Baader. The moment was favourable; the phenomena were not denied, but the doctors went to loggerheads with each other over the theories by which the motions of the divining-rods could be explained.* This is a question into which I do not propose to enter. I am more anxious to inquire into the alleged truth of the phenomena—the presumed power of the rods, that is to learn how they may be explained. In this point of view it seems that M. Chevreul, in his laboured articles in the "Journal des Savants" (1853 and 1854), has (to use the vulgar proverb) put the cart before the horse. We may safely ridicule all that has been said about the moral power of the divining-rod to discover infidelity in women or dishonesty in servants; but it is unphilosophic to say that because table-turning is a trick, therefore there is no virtue at all in the baguette.* We want to know whether there is any "Od force," as Reichenbach might say—any electric affinity—any sympathy—between certain individuals and certain natural phenomena, such as hidden minerals or bodies of water. After weeding all the narratives of their manifestly incredible portions, there is a residuum remaining that still defies our philosophy. If only in one single instance water or minerals have been discovered through the indications of the divining-rod, we should be justified in saying "there is *perhaps* something in it;" but it would not be difficult to find at least a score of instances.

Two or three cases are on record in which persons supposed to possess this divining power were anxious to get rid of it. One Mademoiselle Ollivet, feeling uneasy in her conscience, applied to her confessor, the learned oratorian, Father Lebrun. He told his penitent that thus far her good faith had kept her from sin, but she must now pray God to withdraw the gift of divination by rod, if Satan had any part in it. After passing two days in retreat and prayer, he took the communion, when the rod ceased to turn in her hands. Another young lady, hearing of this case, was equally desirous of being delivered from the suspicious gift. Mademoiselle Martin of Grenoble had often displayed her power over the divining-rod. She

* The curious in such matters may consult Gilbert's "Annalen der Physik," vol. xvii., 1807; and lx., 1819; also Gehlen's "Journal," vol. iv., 1807.

* This much may be said in favour of the hydroscopists, that they never evaded public investigations, as the professed table-turners do.

discovered a bell lying at the bottom of the river, where it had been carried, when the bridge, on which it had hung, had been swept away by a torrent. Believing that her gift came from God, she for a long while resisted the eloquence of Father Lebrun and other saintly men. At last she gave way, renouncing both Satan and the divining-rod. Her mother and sister were much vexed at this loss of power; but it would appear that the conversion was not lasting or very sincere, for, says the holy father, "I heard before leaving Grenoble that the lost virtue had returned to her." Ménestrier, the Jesuit, tells of another young woman, who, after long experience of the powers of the baguette, shrank with holy horror from their continuance. The credulous father gives a copy of a memorandum she had drawn up, describing the peculiar virtues of the rod in her hand. "It answered every sort of question as to the talents or capacities of individuals, their sins and the number of them. It was infallible with regard to the past and present, but was nearly always wrong with regard to the future. The rod would tell how an absent person was dressed, the colour, the materials, and the fashion of the garments. It would reveal the journeys a person had made, the wounds he had received, and on what part of the body." We may congratulate ourselves that rods of such inquisitive propensities are no longer in fashion.

One circumstance connected with these experiments has been too much overlooked; for if it be true it may give a clue to the origin of the supposed virtues of the rod. Jacques Aymar is said to have been remarkably agitated and that his pulse beat as if he were in a fever. Bletton manifested similar emotions: indeed the story goes that when about seven years old, as he was carrying their dinners to some labourers in the field he sat down on a large stone to rest himself; but he felt a sort of "all-overishness" and fainted away and appeared as if suffering from a violent fever. When laid on the grass he recovered, but was attacked by similar symptoms as soon as he was replaced on the stone, beneath which a spring was afterwards found, copious enough to turn a paper-mill. Catherine Beutler also felt strange agitations. Now all legendary exaggeration apart, these instances (and they do not stand alone), would seem to indicate some sympathy—the word is not important—between the "sourciers" and the water, to which the rod may serve as a mere index or conductor. We have not yet fathomed all the secrets of biology, and this may be one of them yet waiting to be solved. We should not look into "All the Year Round" for scientific investigations, but in a description of Amélie-les-Bains

(30th Oct., 1869), there is a passage which bears upon the point under consideration. "Visitors to the Pyrenees have often remarked that while among them, they experience a sort of electrical influence, especially in the neighbourhood of the thermal springs. I have felt this myself. It is like the presentiment of a thunderstorm, which, however, does not come." In this state of the case wisdom bids us preserve a strict neutrality, and meanwhile, should another water-seeker turn up, let us give him a fair trial, and not treat him off-hand as if he were a second Dousterswivel.

THE STRUCTURE OF THE BLOW-FLY.*

THERE are few objects of natural history which are at once so easily accessible and capable of furnishing so much interest to the microscopist, as the common blow-fly. A beginner can readily see enough to supply him with important information, and entice him to further study, whilst the most accomplished anatomist and physiologist will find his powers tasked to the utmost in explaining many points not yet cleared up.

All who are accustomed to look at microscopical preparations will be familiar with the well-known slide of the blow-fly proboscis; but they must be warned that the very elegant and complex object thus presented to them is so far altered and confused by the method of mounting, as to afford very little information of the real character and functions of this highly curious organ. Another common slide object is a portion of the flattened cornea of the same fly, carefully washed, and laid out to exhibit its facets or lenses, with every one of which an optical image may be formed. Here again the mode of preparation, though valuable for certain purposes, leaves very much to be desired; and this is quite as much the case with similarly prepared slides of the adhesive apparatus—the foot-pads—if the term can be employed without reviving associations of highway robbery—technically named *pulvilli*, by means of which this, and many other flies can walk upside down on smooth surfaces, in apparent defiance of the ordinary laws of gravitation.

It is, we fear, too common for the possessors of microscopes to look at a few slides of the description we have named, and to neglect the study of the living insect, or of special organs, carefully

* "The Anatomy and Physiology of the Blow-Fly (*Musca vomitoria*, Linn.)." A Monograph. By Benjamin Thompson Lowne, M.R.C.S. Eng. Illustrated with Ten Plates. Van Voorst.

removed, and examined with as little disturbance of their several parts as it may be possible to effect. Beginners naturally labour under a grave difficulty from not knowing what to see or how to see it, and the scandalous neglect of elementary physiological teaching in ordinary schools affords no preparation for studies which a little wiser training would make easy and delightful.

Nothing can be more useful for the spread of sound knowledge than the study of a good monograph on some object which can be readily obtained, and easily made to illustrate a number of important facts and principles. Such a monograph Mr. Lowne has produced on the blow-fly, and we congratulate him on an unusual amount of success in the avoidance of needless technicalities and difficulties. His work is strictly scientific, and will be accepted as a valuable contribution to insect anatomy and physiology by professional students, while it is nearly all within the grasp of any intelligent person who has acquired a slight popular knowledge of elementary physiology. We should advise microscopists in this condition to set to work with the aid of Mr. Lowne's book, to follow what they find most simple and easy, and to pass over what they cannot readily comprehend, reserving it for future attention. By this means they will insensibly learn much more than they are aware of, and ultimately be able to traverse nearly all the ground over which he passes. On some future occasion we may devote a paper to the subject of insect dissection, but will now content ourselves with reminding beginners that all soft parts must be operated upon under water in a small trough, or in a drop on a slide, according to the size of the object.

Having said thus much, with a view to assuring young students that they must not consider Mr. Lowne's work beyond their reach, we will proceed to a more special notice of its contents.

The peculiar mode in which perfect insects are developed has always invested them with special interest; so much is transacted under our very eyes that our attention is necessarily arrested, and we are compelled to inquire into the curious meanings of what we see. First, we begin with the egg, an object of wonder and mystery, that grows upon us as we try to investigate it. In each egg there is a minute spot or portion, endowed, in what way we know not, with a definite power or force of attracting surrounding matter, investing it with new properties and commencing growth. There is no particular use in calling this force "vital force," and there is obvious logical confusion in the way in which such terms as life, vital, vitalism, etc., are usually employed. Life in the higher animals, or in man,

comprehends a great number of varied and probably quite distinct manifestations. To grow, to digest, to think, to feel—these are all exhibitions of life, but we cannot find any common property between mere growing and thinking, and it is only a dismal pretence of knowledge that makes some would-be philosophers speak of them all as manifestations of "vital force."

In the insect world, as Mr. Lowne remarks, every degree of metamorphosis exists "from that in which the larva, nymph, and imago clearly resemble each other, where the successive changes are merely those of ordinary development, as in the cock-roach, to that in which the change is so complete that it might almost be doubted whether the larva and imago should be considered the same creature at all, so clearly does the process resemble an alternation of generation. This is the case in the fly."

Mr. Lowne has been able to confirm a very remarkable statement advanced by Weissman, that in the fly the head and thorax do not depend for their development upon the corresponding segments of the larva, but that those parts are developed from a series of what he calls "imaginal disks," firmly adherent to the nerves and tracheæ of the anterior extremity of the larva. Dr. Weissman, as cited by Mr. Lowne, says—"I believe in all those insects in which the anterior larval segments are unprovided with appendages (legs) the head and thorax of the imago are entirely redeveloped, whilst in those in which the larva is furnished with legs these parts depend for their formation upon the anterior larval segments."

Mr. Lowne's observations lead him to conclude that "those segments of the fly immediately connected with the functions of vegetative life, those surrounding the anterior portion of the alimentary canal—that is the proboscis—as well as the abdominal segments, are immediately dependent upon the corresponding larval segments for their development and form; whilst the head and thorax, with all their appendages, the chief centres of animal life, are developed from Weissman's (imaginal disks), which do not coalesce with each other until the third day of the pupa state, so that these replace the larval segments from the fourth to the eighth inclusive."

To make this very curious, and, as we suppose we must now call it, highly probable, if not absolutely substantiated theory, more plain to the general reader, we may regard the process of development as proceeding in the following way:—First, the minute portion of developing and growing matter in the egg produces, with the help of surrounding material, the organs and apparatus required by the grub or larva, and it also supplies, or causes to grow in the larva

those "imago disks," or imaginal disks, from which other parts not required in the larval life of the creature, but necessary for it in its final and perfect condition, are in due time to be produced.

Now, if Mr. Lowne's highly probable view is correct, the portions thus superadded belong to a higher form of life than the mere grub was intended to lead. "The brain," he tells us, "seems to form a centre, around which these changes take place; even this organ is entirely altered, but by a process similar to ordinary development." In another passage we are told that "it may be confidently asserted that not one structure exists in the fly as it exists in the maggot. Every portion of the larva, except the brain, and perhaps the prominent membrane of the alimentary canal, undergoes rapid degeneration, and the fly is formed within the pupa skin by a process of redevelopment."

The skin of the fly consists of three layers, the outer one being transparent and continuous. Mr. Lowne states that it is quite insoluble in caustic potash, showing that it is the same as, or resembles that not very clearly defined substance *chitin*.

Mr. Lowne objects to calling this layer a cuticle, as it does not resemble the deciduous cuticle of animals, and he names it *protoderm*, or "first skin"—would not "ectoderm, or outer skin," have been better? A thickening of this outer skin occurs wherever strength is required, and we must remember that the hard outside of insects has to supply the support which in higher animals is afforded by an internal skeleton—an instance of what is common in nature, of two distinct methods of arriving at a given result.

Beneath the outer skin Mr. Lowne calls attention to the layers of epithelial cells, which are best observed in transparent parts of the creature. "The more superficial layer," he observes, "will be found to consist of a single layer of flattened angular cells, containing well-marked nuclei, and beautifully coloured with bright orange-coloured pigment. These cells are about one-thousandth of an inch in diameter, and have a great tendency to adhere at their edges. In the adult fly they form a continuous membrane; but their nuclei become apparent on the addition of a little acetic acid." The layer beneath this consists of somewhat similar cells, "largely supplied with nerve filaments, which ramify in a branching network among them."

Mr. Lowne mentions a curious chemical fact with reference to the pigment in the hard parts of the mesoderm or middle skin, and the deep blue colour of which depends on the oxydation of the pigment. This substance exists in the fatty bodies, and when cut and

exposed to air becomes inky black. When the perfect insect first emerges from the chrysalis it is pale, and as its respiration proceeds, the oxydation of the pigment takes place, and then it may be said to paint its colours as it breathes.

Before studying Mr. Lowne's chapter on the nervous system of the fly, we should advise those of our readers who may not have observed the arrangement of ganglia and nerve-cords in an insect, conforming to Owen's Homoglangliate type, to catch a young transparent cock-roach or "black-beetle," then a pale brown fellow. He is transparent enough to show the two sets of ganglia and connecting nerve-cords which supply the nerve power by which he lives, and may be instructively compared with the very different arrangement of similar organs in the blow-fly, concerning which Mr. Lowne says, "No insect that has been examined departs from this (homoglangliate type) so much as the fly and its allies; for even in the larva state the whole of the nervous system is collected in the anterior segments, and the pair of ventral cords do not exist, whilst in the imago, with the exception of two small ganglia in the proboscis, there are but two nerve centres, one situated in the head, and the other in the thorax." Mr. Lowne cannot mean that no nerves whatever are supplied to the posterior segments, though his words would bear that interpretation.

The two great ganglia are the cephalic (in the head), and the thoracic (in the thorax) and if the observations of Mr. Lowne on the former should—as it is only fair to him to anticipate—be confirmed, we shall find in the fly and its allies evidences of progress towards a higher type of organization than insects generally possess. He says, "A more positive indication of a higher type of organization than even the relative bulk of the sensory ganglia" (which is large) "is found in the fact that two very remarkable convoluted nerve centres, connected by a commissure, each about one-thirtieth of an inch in diameter, surmount the cephalic ganglion, and are connected to it by a pair of distinct peduncles. These are extremely like the pedunculated convoluted nerve centres which occupy the same position in bees and ants, first described by M. Felix Dujardin, and considered by him as analogous to the cerebral lobes of the higher animals." M. Dujardin did not succeed in detecting these organs in the fly, but Mr. Lowne tells us he was led to expect he should find them from the superior intelligence manifested by that insect, many of its acts bearing evidence of memory, such as the avoidance of a person who is pursuing it, and which looks like more than reflex action. He adds, "Nevertheless, it must be conceded that

most of the acts of insects are probably entirely reflex, or the result of impression from without, and this coincides with the comparative bulk of the organs of sensation over that of the higher nerve centres." This is certainly true, but we agree with the limitation conveyed by the word "most," as well as with the general proposition. We noticed a few months ago, a curious instance of disturbance in the memory of some bees who had been chloroformed, and passed a long night under the influence of that anæsthetic. In the morning those which recovered life and motion seemed to have a defective recollection of their former home. They were puzzled to recognize the entrance to their hive, the lower part of which had not been disturbed. Their memory was evidently paralysed, or in a fog, such as sometimes happens in the case of bipeds who have taken a drop too much, and stagger in bewildered hesitation before their own street door.

From the disposition of the nerve centres of insects, and the want of that decided predominance of the brain over the whole system which we find in the vertebrata, taking their heads off does not rapidly lead to the death of their bodies. Mr. Lowne informs us that "when the head is removed from the fly there is nothing more striking than the different character of the phenomena exhibited by the parts. In the head, a convulsive movement of the tongue and antennæ follows the division of the nervous cord which unites the two nerve centres; this continues, at most, a few seconds; but no reflex act follows the application of external stimulus afterwards. Of course we cannot tell to what extent the functions of the cephalic ganglion remain; but their duration is probably short. Perhaps they cease as soon as the nerve of communication between the head and the thorax is severed. On the other hand, though the trunk continues to manifest signs of life for many hours, no movements, except those which result from the stimulus or shock produced by dividing the great cephalo-thoracic nerve-trunk at the moment of division, takes place, except the respiratory movement of the abdomen, till some external stimulus is applied." It appears that a very slight stimulus will call such movements forth for hours after the decapitation has taken place.

Mr. Lowne ascribes to the fly, as may be judged from the extracts we have given, a more complicated and higher nervous organization than Prof. Huxley assigns to insects generally; but this is a subject on which we will only now remark that we incline to Mr. Lowne's views.

The nerves of the viscera are derived from a separate system of

ganglia, the chief of which is situated at the junction of the thorax and abdomen.

We do not propose to follow our author throughout his investigation, but to note here and there matters of general interest to our readers, and they will learn with surprise how the wings are moved. It seems startling to say that the "real muscles of flight are not connected with the wing at all. They consist of a longitudinal mass, which fills the greater portion of the back, and the wings are so attached, that the flank forms a kind of fulcrum, upon which they are elevated or depressed by every alteration in the convexity of the back. The great longitudinal dorsal muscles, by shortening the thorax, increase its convexity and depress the wings, which are again elevated by the flattening of the back and lengthening of the thorax, due partly to its own elasticity and partly to the action of the lateral thoracic muscles, which are vertical in their direction. So that, in point of fact, the flight of insects is merely a modification of crawling, both being affected by the alternate approximation and cohesion of the several segments. This may be confirmed by direct experiment; for, by taking a recently killed fly, and using a pair of dissecting forceps, placing one blade behind, and the other in front of the upper part of the thorax, the movements of flight may be produced by alternately compressing and releasing the forceps. The wings should be extended, in order that the full effect may be seen. The amount of alteration in the convexity of the back which is sufficient to depress the wings to their fullest extent, is so slight, that it is scarcely perceptible to the eye."

Thus two modes of motion, the most apparently opposite, crawling like a grub, and flying through the air, are both produced by analogous means. The insect wing, though performing the same function, is widely distinguished from that of the bird.

We fully agree with Mr. Lowne, as regards the walking of flies, in rejecting the notions of suckers and prehensile hairs. The principal hairs of the pads secrete a viscous fluid sufficiently sticky to keep the insect from falling, but not so much so as to prevent the easy removal of its feet by a slanting and sliding movement. Flies are sometimes found dead and stuck fast, the gummy fluid having hardened, probably after their decease, or from disease of the secreting organs.

The bluebottle's proboscis is an admirable apparatus for sucking in fluid food, and for grating up and dissolving solids, like sugar, in the abundant salivary secretion poured through it. This instrument can only be appreciated by watching its action in live flies, loosely

confined in live boxes, with a drop of nutriment to suck, after which dissections and preparations may be made; but they are only reliable if care is taken not to squeeze the parts out of position and shape. Squashing them in hot balsam is a very unscientific performance, though a pretty slide may be the result.

The general appearance of the proboscis is familiar to all who have watched a fly feed. A sort of horse's head looking object is applied to the food, and this, when its two terminal lobes are separated and the whole flattened, forms the well-known slide object in which a series of imperfect tracheal tubes are the most striking features. These channels, kept open by segments of rings, form a series of strainers through which only fluids and minute particles can pass. They are evidently modifications of the tracheal or breathing tubes, though their function is quite different. Mr. Lowne's plate of the proboscis is the least successful of his illustrations. Mr. Suffolk has succeeded much better, though he has drawn from specimens swollen abnormally by imbibation of the mounting fluid. The student, in examining this object, should look for the remarkable series of teeth—fifty or sixty—"which are usually concealed between the posterior portions of the lobes." They are rod-like bodies, notched into low teeth at the ends.

We could not make the details of the digestive system intelligible without plates, and for these we must refer our readers to Mr. Lowne's work. The proboscis transmits the food to the pharynx and thence it reaches the œsophagus, which bifurcates on entering the thorax. "One branch passes upwards, and immediately opens into the proventriculus, or crop, the other runs the whole length of the thorax, beneath the chyle stomach, and passes into the abdomen under the intestines." The "sucking stomach" does not exist in the larva, but is developed from a bud. "It serves as a reservoir for the food when first taken, the chyle stomach extends the whole length of the thorax," and the small intestine extends from the stomach to the opening of the bile tubes, which perform the functions of a liver. In the rectum are certain papillæ supposed to be urinary.

Mr. Lowne observes that "the analogy between the functions of the crop, proventriculus, and the chyle stomach, and the crop-rennet and paunch of ruminants is too obvious to need enlarging upon. But the resemblance of the digestive act in the two cases is even closer, for the fly frequently brings its food back to its mouth, probably for the purpose of mingling it with the saliva."

The organs of sense of the blow-fly consist chiefly of the great

red eyes, the ocelli, the antennæ and palpi, to which Mr. Lowne adds the halters, or poisers, and the "frontal sac," which latter, he thinks, may take note of coarser odours than the antennæ may observe. The real functions of the antennæ of insects are still in doubt. Perhaps they are complicated, and not precisely analogous to any sense we possess. Mr. Lowne adopts the view that the halters are auditory organs, but this requires investigation.

We have probably said enough about the blow-fly to excite renewed interest in its study, and to afford an idea of Mr. Lowne's excellent work. While doing full justice to and recognising the labours of his predecessors, he is entitled to great consideration as an original, expert, and painstaking investigator. Some of his opinions will, no doubt, be questioned and perhaps disproved, but all will admit that his monograph is a very valuable contribution to microscopical science. His plates are very good, but in another edition we should advise more detailed references to all the parts and figures. Upon many anatomical and physiological matters discussed in his book we have not entered, as being unnecessary for or unsuitable to our present purpose, which is not only to introduce and recommend his researches to the consideration of our readers, but also and especially to lead on those who may be commencing such pursuits.

REMINISCENCES OF DREDGING.

BY THE REV. THOMAS HINCKS, B.A.

The dredge has acquired a popular reputation of late; it has received the patronage of government, and its exploits have found their way into the general newspapers. It has solved a great mystery, and brought us authentic tidings of a realm which seemed to lie beyond the range of our investigation, and about which we could only theorize vaguely, and, as it proves, falsely. The popular imagination has been excited by accounts of an abysmal region, almost as far *below* the level of the sea as the summit of Mont Blanc is above it, where, in an Arctic climate, without light, and beneath an enormous pressure, whole tribes of beings have their home; and by the discovery of animal forms, more like the survivors of a vanished epoch, which in these profound depths have lingered on into the present, than portions of the existing *regime*. Strange Crinoids, and gigantic *Foraminifera*, and antique Sponges, recalling the fossil *Ventriculites*, have been dragged into the daylight, linking our era unexpectedly to that of the chalk; or rather bringing us to the startling conclusion that the Cretaceous epoch has not yet passed away, but that we ourselves are living in it. Then we have received tidings of the mysterious *Bathybius*, that strange organic slime, which penetrates the ooze of the deep-sea bottom, and in which we seem to recognize the very beginnings of life. And for all this we are indebted to the dredge; to the dredge is this sudden extension of the kingdom of life due, this discovery of the "lost tribes," this unveiling of secrets that had hitherto been kept inviolate; and for the moment a special interest attaches to the rough iron frame and bag, which have long been the useful servants of the naturalist.

I do not propose in this paper to deal with any of the interesting questions that have been brought into prominence by the recent deep-sea dredgings. Nor have I a tale to tell of the stirring incidents familiar to those who investigate the fauna of the ocean in remote and stormy waters. I have no more ambitious design than to chronicle some of the quieter experiences of the in-shore dredger, who works in moderate depths, and for the most part under easy circumstances, but amidst a rich and varied profusion of life.

And so far as the minute investigation of structural and physiological problems is concerned, the latter enjoys advantages which

are altogether wanting to his more adventurous brethren. He has his compensation for the absence of exceptionally startling results in the facility with which he can deal with his material, and the patient and continuous study which he is able to bestow on the objects collected. After a cruise of two or three hours on comparatively tranquil waters, and beneath a summer sky, he returns unexhausted to his microscope, and conducts under the most favourable circumstances a thorough examination of his spoils. He is also within easy reach of his dredging ground, and has the chance of renewing his supply of the animals to which his attention is specially directed; and is thus most advantageously placed for pursuing the fascinating and fruitful study of development. Nor is it the least of his privileges that he escapes in great measure the frightful miseries of sea-sickness, and if overcome at any time, can easily take refuge in smooth water!

The paradise of the dredger and marine zoologist, so far as Great Britain is concerned, must certainly be sought in the west of England, and if required to localize it more definitely, I should place it in Salcombe Bay on the lovely coast of South Devon, which offers the rarest combination of favourable circumstances, and is as remarkable for the beauty of its shores as for the fertility of its waters. In these days, when the most sacred spots are liable to be profaned and vulgarized by cheap trips and troops of noisy excursionists, one would hesitate to direct attention to this charming retreat, if Salcombe were not happily placed "beyond railways," and destitute of the peculiar attractions that invite the incursion of the summer hordes. It is truly out of the world, and long may it continue so!

The Bolt Head, one of our most majestic headlands, the companion of the Prawle and the Start, guards the entrance to the Kingsbridge estuary, a fine arm of the sea which stretches away inland for about five miles, now expanding into lake-like sheets of water, now branching off into creeks and inlets, and bordered throughout its whole extent by a rich and happy country. A short distance from the mouth of the estuary, and within the sheltering embrace of the Bolt, is the little town of Salcombe, lying along the edge of the water; commonplace enough in itself—not to use a more uncomplimentary term—but charming from situation and with a delightful outlook. The veritable Montpellier of England, where the aloe blooms, and the citron fruits in the open air, it is celebrated in the "Cosmos" for its genial and equable temperature. I can testify to the extreme beauty, though not to the quality of its

citrons, and to the surpassing excellence of the peaches and nectarines ripened on its sunny slopes.

But I am not describing Salcombe, or I should have much to say of the unique loveliness of the views from the town and its immediate vicinity; of the walks on the neighbouring headland, so full of interest both to the lover of scenery and the naturalist; of the physiognomy and changing aspects of the mighty Bolt itself; and of the smiling shores of its pleasant waters. I am concerned with the place, at present as a station for the dredger.

His ground extends from the mouth of the estuary to a little beyond its first decided bend, some distance beyond the town; and within this range the most favourable general conditions combine with certain local specialties to render both fauna and flora singularly rich and interesting. A vast body of the warm, clear water, that bathes the western shores of England, flows with each tide through Salcombe Bay, on its way to the upper and shallower reaches of the estuary; and here we have the freshness and crystalline purity of the open sea, with the shelter and quietude of a great aquarium. A bit of the ocean is here embraced by the land, and guarded from the extreme fury of the winds, while exposed to all the influences of a most genial climate, and is thus converted into a rich preserve of animal life, and a tranquil highway for the naturalist.

You step almost from the main street of the town into your boat, and in five minutes you may cast the dredge on productive ground, and soon bring a plentiful harvest to the surface. No long sail before business can be commenced; no dread of nausea; no fear of the savage squall bursting upon you when far from land, and driving you home in the very moment of expectation! Rough weather there is, of course, at times, and sudden inroads of sea-fog, blocking up in a few minutes the mouth of the estuary, and shrouding the grand outlines of the Bolt; but you are never far from shelter and the microscope, and these incidents involve little loss of time or money. Dredging in Salcombe Bay is rather a luxury than a labour. Floating dreamily on its quiet waters in summer time, with the pleasant corn-fields close at hand, you soon gather a rare assemblage of animals, corresponding with the varied character of the ground. Now the dredge is cast upon a fine scallop-bank and comes up laden with large empty shells, each one of which (to speak *more Hibernico*) is filled with curious forms of life—a perfect museum in miniature. Now it is dragged over the rough ground in the centre of the channel, and returns crowded with a miscellaneous

collection, in which the *Tunicates, Echinodermata,* and *Zoophytes* are specially conspicuous. Now it sweeps the sub-marine meadows of *Zostera;* now it tears from the rocks that fringe the shores long, trailing masses of *Halidrys,* brilliant with the gorgeous stars of the *Botryllus,* and thickly festooned with some of the prettiest of the *Vesicularian Polyzoa.*

In Salcombe Bay I first made acquaintance with the Feather-Star (*Antedon rosaceus*);* and the impression produced by the sight of its extraordinary beauty is fresh and vivid still after the lapse of twenty years. It is gregarious in habit, and at certain spots the net of the dredge, as it rose from the water, was studded with the most glorious specimens, while the masses of weed inclosed in it had each of them its splendid galaxy. Some scores of the *Antedon* were cast overboard after each haul, and it was a sight not to be forgotten, to see them expanding as they touched the water—rose-coloured or of the deepest, richest red, pale yellow, or barred with yellow and rose—and then sinking slowly and gracefully, like a shower of brilliant blossoms, to the depths. On the dark weed, to which they attach themselves by their hooked filaments, they almost seemed to glitter like veritable stars. When dredging subsequently in Salcombe Bay I have never met with the *Antedon* in such profusion as on my first visit to it; it may congregate for the breeding season, or it may be local like others of its kindred, and rather gregarious at certain points, than generally diffused. This is the case with many of the *Echinodermata,* as every dredger knows to his cost. It is not unusual to meet with an enormous assemblage of the common Brittle-Stars (*Ophiothrix fragilis*), which within a very limited area seem to have the sea-bottom to themselves, while beyond this narrow territory not a specimen is to be found. It is a serious annoyance to fall in with one of these Echinodermal mobs. The dredge begins to ascend heavily weighted, and you watch with eager impatience the coiling of the rope, and please yourself with the thought of the treasures that are on their way. It emerges from the water, and in an instant is emptied before you; and there lies, to your immense disgust, a wriggling mass of interlacing, intertwining star-fishes—*pur et simple*—without an admixture of any nobler game. You pitch them overboard in all haste, and fly from the spot as quickly as your oars will

* Alas, for the familiar names by which our old friends were known to us! In spite of all æsthetic and sentimental pleas, we have lost the classical *Comatula,* with which so many pleasant associations were connected, and have got an *Antedon* in its place.

carry you, never to return, if you can help it! In Torbay, another zoological Eldorado, I have come suddenly on an extraordinary concourse of this kind, but on shifting the ground very slightly, all trace of it as suddenly vanished.*

To return to the *Antedon*, not only was the adult Feather-Star abundant in Salcombe Bay, but it also yielded an unlimited supply of the Pentacrinoid young. It was a common occurrence to dredge up bunches of weed profusely covered with it in every stage of development; and if the brilliant beauty of the mature animal was charming, still more fascinating was the romantic history of the young, commencing life in the likeness of an extensive tribe that has well nigh vanished from the earth, linking the fossil Crinoid to the modern Star-fish, and, as it were, summarising in its little course "the long results of time." The recent labours of Dr. Carpenter, Professor Wyville Thomson, and others, have thoroughly elucidated the structural and developmental history of the Pentacrinoid, but they have added little to the interest of J. V. Thompson's original discovery, that the free Feather-Star is genetically connected with the fixed Crinoid, and that the ancient Encrinitic races in their decay are not only represented by a poor remnant of adult forms, but also by the young and fugitive condition of a higher organism.†

The *Echinodermata* usually form a conspicuous and important element of the produce of the dredge; and it was so in Salcombe Bay. Now the sombre heap of "stuff" was lighted up by a

* Some of the *Echini* are also remarkable for their social and gregarious habits. In the course of the late deep-sea dredgings, it is stated, a single haul of certain hempen tangles, contrived for sweeping the bottom of the ocean, brought up an amazing number (some thousands) of a species of *Echinus*. In the last British Association Report on the Shetland dredgings, Mr. Norman tells us that "forty miles east of the Whalsey Skerries *Echinus Norvegicus* was in such extraordinary profusion, that the dredge came up again and again, literally almost filled with it; but though occurring in many other localities it was, save in this one instance, comparatively uncommon. Near the same spot, *Antedon Sarsii* was brought up in thousands; ye except in this one day's dredging, I was never fortunate enough to meet with the species." Dr. Collingwood ("Rambles of a Naturalist") found on a reef in the China seas, patches of dark purple Echini, containing from 50 to 100 individuals, so closely packed as completely to conceal the sea-bottom.

† In a paper read before the French Academy of Sciences, M. Lacaze-Duthiers, as we learn from "*Nature*," has called "the attention of naturalists to the harbour of Rosooff, on the north coast of France, as a locality where the young form of *Antedon rosaceus* is to be found in abundance." The editor adds, that "from his description, the Bay of Roscoff is a paradise for the student of marine zoology." I have no acquaintance with this locality; but I will venture to back the Bay of Salcombe against it, both as a habitat of the Pentacrinoid, and as a paradise for the zoologist.

gorgeous Sun-Star (*Solaster papposus*), now by the milder glory of the kindred *Solaster endeca.* But omitting the smaller forms, the species which (after the *Antedon*) connects itself most closely in my mind with the locality, is the noble *Asterias glacialis* (*Uraster glacialis*, Forbes), examples of which were of frequent occurrence, distinguishable at once by their large size, their spinous surface, and their exquisitively glaucous tint. They blend with the brilliant Feather-Stars, the festooned *Halidrys*, the Scallops crowded with sculptured corals, the pleasant corn-fields, and the glorious headland, in my recollections of Salcombe Bay.

Those who have had no experience of dredging can have little idea of the variety and beauty of the colours of marine animals. They are most evanescent, and even in the best preserved specimens there is little more than a bare suggestion of the original splendour. In a large proportion of cases the delicate and vivid hues utterly disappear, and in the collection the living structure is represented by a pale and ghost-like form. Colour, however, is a striking feature of marine invertebrate life. Amongst the Echinoderms, the roseate tints of the *Antedon*, and the purple and gold of the *Solaster*, are rivalled by the rich and varied painting of the Brittle-Stars. Though the shells of the British seas are, for the most part, of sober colouring, their inhabitants are often most gaily decorated, witness the orange mantle of the Cowry, the golden fringes of the nest-building *Lima*, the coral-red and the brilliant ocelli of the *Pectens*—"the butterflies of the ocean." But in one section of the *Mollusca*—the Sea Slugs (*Nudibranchiata*)—the beauty of colour is such that a parallel to it can only be found amongst the fairest of floral tints. These graceful creatures—for there may be grace even in a Slug, as anyone who has studied their movements will readily admit—are commonly tinged with the most exquisite dyes, or painted with the richest patterns, a peculiar delicacy and tenderness being imparted to the colours, by the perfect transparency of the tissues. The members of this lovely tribe are abundant in Salcombe Bay; the most beautiful forms come up frequently in the dredge, showing as brilliant specks of jelly, and looking like little gems; and it was pleasant to meet occasionally with one of Montagu's rarer species, reminding us that we were on the classical dredging ground of this admirable naturalist.

But to complete this digression on colour, the *Tunicates*, many of which look dirty and dingy enough in their leathery coats, number in their ranks some of the gayest of the inhabitants of the sea. I have already referred to the *Halidrys* and its parasitic splen-

dours; nowhere, I think, have I seen such a glory of marine colouring as was exhibited by the star-spangled crusts of the *Botryllus*, investing the stems of this populous weed. The large bunches of it, which were continually torn from their attachment, were quite gorgeous with the masses of green, blue, yellow, olive, adorned with their radiate patterns, which form the colonies of these sociable Ascidians. The multitudinous host of the kindred *Polyzoa* is rather distinguished by elegance of form and delicacy of minute sculpture than by bright colouring; but even amongst them, the *Lepraliæ*, which constitute an extensive genus, and the stony crusts of which overspread profusely the most diverse marine substances, exhibit a rich variety of tints, and, like the lichens on the wall, light up the monotonous surfaces of rock and stone, I have noticed the following colours, reds and yellows of various shades, and some of them of great intensity, purple, grey, brown, delicate lilac and cream, orange, and silvery-white; and no doubt the list might be considerably increased. A large stone dredged from thirty fathoms' depth off the coast of Cornwall bears an extraordinary collection of these *Lepraliæ*, including many of the finest and rarest species, and its surface is tessellated with variously coloured patches, and presents a most richly variegated appearance. As the sterility of the remotest Alpine solitude is relieved and brightened by the humbler forms of vegetation, so the common stones of the sea-bed are profusely decorated with the sculptured and tinted crusts of the moss-coral.

The *Annelids* would alone furnish material for a long chapter on colour. The gorgeous crowns of the tubicolous kinds are familiar to every keeper of an aquarium, and to those who investigate the wonders of marine life amongst the clefts and ledges of the rocky coast, as well as to the dredger. The long, wriggling worms that so often occur to the latter, and which might otherwise be viewed with repugnance, compel our admiration by their vivid colouring and almost metallic lustre. It may be added that many species of Annelids are luminous in the dark, and exhibit coloured lights.

The Zoophytes (*Cœlenterata*) in their two great divisions, afford us many striking illustrations. Of the *Actinozoa* it is hardly necessary to say much here. Every one is more or less familiar with the flower-like forms of the *Actiniæ*, and has heard of the glories of the coral-reef—glories which have stirred the enthusiasm and inspired the eloquence of a long succession of naturalists and voyagers. On the Devon coast you may find humble representatives of the great coral-making family in the Madrepores (*Caryophyllia* and *Balanophyllia*), humble in size, but in colour not unworthy of the race which

has built the reefs of the Pacific. In the same region the dredge brings up the tree-like *Gorgonia,* glowing with the richest pink, a fitting companion for its tropical congeners, and reminding us of "the yellow and scarlet tufts of ocean" which the poet has celebrated.* In Salcombe Bay, the Anemones appear in the greatest profusion and splendour, but they belong to the shore collector rather than to the dredger. I have taken from a rock-pool a small stone bearing upon it a group of no less than thirty of the rare and exquisite *Corynactis,* of the brightest velvety green, and with vivid ruby tips to the arms—a perfect galaxy of little gems.

In the *Hydroid* section of the Cœlenterates colour is a less striking feature; but even here the *Athecate* (or *Tubularian*) polypites are often brilliantly tinted, and give to the plant-like tufts the appearance of being thickly clothed with starry blossoms. The colours that prevail amongst them are the various shades of red,—rose, crimson, pink, vermilion, scarlet,—and occasionally orange and yellow. A large specimen of the strikingly arborescent *Eudendrium rameum,* some six inches in height, bearing aloft its hundreds of red flower-like polypites, and laden with its bright yellow ovaries, rivals in miniature the splendour of some tropical tree, and is a really beautiful sight. On the heap of stuff which the dredge has brought up it lies, with all its parts folded together, a dingy and shapeless mass; you plunge it into one of your bottles filled with sea-water, and instantly, as if by magic, it expands into the semblance of a well-grown tree, and multitudes of rosy blossoms bloom on every branch. But the free-floating Hydroida, known till lately as "Naked-eyed Medusæ," which are most of them the reproductive members o fixed Hydroid colonies, bear off the palm for this kind of beauty In them, as in the Nudibranchs, the most varied and vivid colouring is combined with crystalline transparency of tissue.

I can barely mention the Sponges; the scarlet and orange of their soft cushiony masses clothing the bare surfaces of the rock, may be ranked with the wonderfully deep and tender green of the fresh moss-tufts on the wall, and the saffrons and sulphurs of the lichens on the mountain-side, as examples of what Nature can do in the way of chromatic decoration. It only remains to add that the late deep-sea dredgings have established the remarkable fact that the profound abysses of the ocean are not destitute of the beauty of colour, but that even in these sunless regions there are brightly-tinted shells, star-fishes, annelids, corals, and sponges.

This digression has been long, yet not unnaturally has it con-

* Percival in "the Coral Grove."

nected itself with Salcombe Bay, for in its sheltered and genial waters life shows itself in the utmost luxuriance, and colour at its brightest.

But we must hasten to the scallop-bank, which, no less than the oyster-bed, is a favourite ground with the dredger; not, however, be it remarked, for the sake of the edible mollusk which it supplies. My agreement with the boatmen has generally been that I should have all the empty shells, but that the full ones should be theirs; an arrangement perfectly satisfactory to them, but which, I fear, had a damaging effect on their estimate of my common-sense!

Not easily to be forgotten were the large masses of the beautiful Polyzoon, *Salicornaria farciminoides*, rising from a brilliant carpeting formed by an incrusting sponge, which the dredge tore from the rocks in this locality. The delicate white moss-coral looked like a carving in ivory set on a piece of scarlet velvet, ready to be placed, as it was, under a glass shade! Such charming combinations frequently occur to the dredger; they enter into no systematic natural history, but they are minute, and as it were casual traits of the beauty of nature which deserve a record.

This Polyzoon, it may be remarked in passing, is a favourite haunt of the Pentacrinoid young of *Antedon rosaceus;* here and elsewhere I have found the little Crinoid upon it in great profusion. The *Salicornaria* has an extensive range in depth, and is also very widely distributed; on our own coasts it occurs commonly, as in Salcombe Bay, in shallow water, but it has been taken up on a portion of the telegraphic cable* that formerly connected Sardinia and Algeria, from a submarine valley, which is from 1000 to 1500 fathoms deep, so that it must be very independent of external conditions.

The dead shells of the *Pecten maximus*, however, were the glory of the scallop-bank—dead, but crowded with life; emptied of their original tenants, but occupied by a thousand lodgers instead: the homes of individuals once, the homes of whole tribes now. Few things give one a better idea of the profusion of life in the sea, and the beauty of minute organic structure, than the study of one of these colonized shells. Within the shelter of the concave valve are gathered representatives of the most various groups. There are few waste spaces; the obscurest corners and crannies have their occupants. The *Polyzoa* monopolize the largest portion of the

* The Mediterranean cable afforded M. Alphonse Milne-Edwards a suggestive glimpse of the life of the deep sea, which has helped to stimulate the desire for further investigation.

territory; the tinted crusts of the *Lepraliæ* overspread and diversify much both of the inner and outer surface, mingled with the silvery lacework of the *Membranipora*, glistening with its pearly ovicells; the delicate chains of the fairy *Hippothoa* creep in and out amongst the larger forms; and in the centre, it may be, rises an exquisite shrub-like tuft of the ivory *Crisia*. But the striking feature of these Salcombe scallops was the great number and beauty of the tube-dwelling *Polyzoa* (*Cyclostomata*). In this section the colonies consist of clusters or companies of delicate stony tubes, disposed in various patterns, each with a polypide as its tenant. Sometimes they rise into erect and branching corals; sometimes they form lobed and circular crusts, or creep in dendritic fashion over shell and stone. On these scallops they flourish literally in wild luxuriance. Large flower-like discs, tinged with purple, their margins deeply cut into many lobes, stud the inner surface here and there; while, crowded round them are other forms, circular, stellate, fan-shaped, all bristling with frosted tubes, and making the old worn shell a very shrine for the lover of beauty no less than for the naturalist. The *Annelids* are represented by the *Serpulæ* in their stony cases; gay *Tunicates* find a home within the sheltering enclosure; the Campanularian Zoophyte overspreads the moss-coral with its tiny cups; often the Cowry, in its orange robes, joins the permanent dwellers for a season; hosts of minute crabs hide in the chinks and crevices, and the very substance of the shell itself is filled with the burrows of the perforating sponges, which will ultimately compass its disruption and the dispersion of the tribes that have found a resting-place upon it. The outer surface is also more or less covered with the crustaceous species, and often adorned with the graceful tufts of *Bugula plumosa*. And all this life is independent of the humblest and minutest forms; of the Protozoan population borne on the single valve I cannot pretend to give the census.

The dredge seldom came up in Salcombe Bay without bringing with it a miscellaneous and motley collection of creatures that was truly wonderful to look upon. I wish I could, as it were, photograph a single haul as it lay in the boat, awaiting examination; but the details are lost, and I can only recal the general effect, and the most striking objects. The *Tunicates* frequently formed a conspicuous element. Besides the smaller species, which abounded, clustering in coloured masses on weed or stone, some of the larger kinds occurred in much profusion. Often, to our great disgust, the dredge came up half filled with a multitude of a dirty-looking,

leathery sort (*Ascidia sordida ?*), which emitted a most sickening smell, and wonderfully increased the effect of troubled waters or the long tidal swell, on head and stomach! We found it expedient to get rid of them as speedily as possible. A large whitish species, with a nodulated surface and a strangely porcellanous appearance, which I have not met with since, was a common and striking object. Around these examples of the stillest of still life—creatures shut up in a bag, with no external organs, and only communicating with the outer world through two small orifices—a host of active crabs shuffled about, presenting all varieties of the grotesque: crabs little and crabs large, crabs round and crabs square, crabs smooth and crabs rugged, crabs with a house and crabs without! The Hermits were always in great force, and those curious spider-crabs, in which the body seems to have abdicated in favour of the legs. Here a large Sun-Star, lying brilliant but inert; there a Brittle-Star, striding nimbly away! Here two or three *Aplysiæ* pouring forth their dark fluid; there a spotted Anemone (*Adamsia palliata*), glowing with red, purple, and pink, and joint-owner with a hermit-crab of an old Trochus shell! And, by the way, a curious and pleasant chapter might be written on the alliances existing, as in this case, between different animals. Here a Whelk, bearing a fine specimen of the Parasitic Anemone (*Sagartia parasitica*); there another in the possession of a Hermit, and invested by a colony of the beautiful hydroid, *Hydractinia echinata*. This zoophyte spreads over the surface of univalve shells, as a white fleecy covering, which, on examination, resolves itself into a multitude of graceful polypites, supported on an incrusting base. On certain portions of this common crust are placed slender tentacular filaments, which are capable of great extension, and have been regarded as fishing-lines, by means of which the *Hydractinia* seizes and appropriates the crumbs that fall from the Hermit's table. The alliance between the two, though not constant, is very common, and whatever it may yield to the crab is no doubt of material advantage to the zoophyte. Many of the minute zoophytes secure the benefits of locomotion, and probably supplies of food, by planting their colonies on the shells of the mollusk, and they often select the operculum as their site. Returning to our heap—sponges, of a deep orange colour, enveloping small univalve shells, from the opening of which a Hermit looks saucily out, lie scattered about it; stones overgrown with corallines, and others bearing colonies of the pretty compound *Actinia* (*Zoanthus Couchii*), and old shells, in the hollow of which the rare *Calyptræa* nestles, and brilliantly coloured

worms coil themselves, and the small *Echinus* shows its purple spines, and the moss-corals spread in rich profusion; and bunches of weed glittering with Feather-Stars, or gay with the *Botryllus*, or hung with the exquisite plumes of the "Podded Coralline" (*Aglaophenia pluma*). A rough sketch like this, however, can give little idea of the reality; but it may suggest in a general way the affluence of life and beauty which rewards the toil of the dredger in these prolific waters.

But now our boat floats over the submarine meadows of the *Zostera marina*, and we look down through the clear water upon its long slender leaves of the brightest green, on which troops of small univalves congregate, and the pretty Campanularian Zoophyte *Clytia Johnstoni*, displays its ringed pedicels and crystal cups, or the *Plumularia* (*P. echinulata*) hangs its plume-like shoots; while studding them, here and there, are numbers of the beautiful Anemone, *Anthea cereus*, looking like full-blown flowers, and waving to and fro with every movement of the water. It is a charming scene, and we leave it with reluctance to cast the dredge under the rocky wall of the estuary at the opposite side. Here we are in the region of the *Halidrys siliquosa*, the most productive of Algæ to the zoologist. I have already referred to some of the *Tunicates* and *Polyzoa*, which invest it; to these must be added the beautiful Zoophyte, the "Podded Coralline," between which and the *Halidrys* there is a close alliance, and which covers the weed with its netted fibre and graceful plumes. But the fairest parasite of the *Halidrys*, and perhaps the chief glory of Salcombe Bay, zoologically viewed, is the *Mimosella gracilis*, a Polyzoon, unique in some respects, and of which this is the original habitat.* It belongs to the Vesicularian family, the members of which exhibit a decided preference for this weed, and climb over it with a kind of tropical luxuriance. The striking characteristics of the *Mimosella* may be briefly given, without resorting to technical phraseology. It forms luxuriant confervoid tufts, much and irregularly branched, which rise from a delicate fibre spreading over the surface of the weed; the main stems, which are horny in substance, taper upwards, and run out into tendril-like prolongations; the branches are opposite, and bear the oval cells of the polypides, ranged along each side in a double series. But now comes the distinctive peculiarity; the cells, instead of being fixed, as in all other known *Polyzoa*, are so constructed that they can be swayed to and fro by their tenants, on a kind of joint at the base. This movement

* I have only found the *Mimosella* in one other locality. When dredging in Torbay, it occurred on masses of the *Halidrys* torn from the submerged base of Berry Head.

FIG 2, X 900

FIG 3, X 900

FIG 1, X 900

FIG 4, X 900

FIG 5, X 2000

FIG 8, X 825

FIG 7, X 1400

FIG 9, X 1800

SCALES OF LEPIDOPTERA,

Their minute structure.

of the cells always accompanies either the retraction or expansion of the polypides; when about to issue from their little dwellings they throw back the cell, and then instantly dart forth; as they withdraw, the cells on the pinnæ fold together, like the leaflets of the *Mimosa* when touched. Every now and then, I have noticed, as if some common impulse stirred them, all the polypides on a single pinna will move forward their cells and the *quasi* frond close, like the leaf of the Sensitive Plant, if irritated; but more generally they are independent of each other. Most interesting it is to watch these movements; to watch the animal sensitive-leaf closing, and then polypide after polypide flinging back its cell and expanding its exquisite bell of tentacles. It is a sight not to be witnessed without real enthusiasm by any genuine naturalist.

And is it not a chief recommendation of the true study of nature that it is constantly eliciting these simple but intense enthusiasms, which help, with other things, and more than most things, to keep a man's heart fresh and young, and pure?

THE SCALES OF THE LEPIDOPTERA: RESEARCHES OF DR. PIGOTT.

BY HENRY J. SLACK, F.G.S., SEC. R.M.S.

(*With a Plate.*)

Dr. G. W. Royston Pigott has recently astonished the world of microscopical observers, by telling them very plainly two startling, and to many unwelcome, *truths*, for such we must pronounce them. Firstly, he says that they have not seen their favourite test object, the Podura scale (*Lepidocyrtus curvicollis*), properly; secondly, that their best object-glasses are afflicted with sufficient spherical aberration to have rendered the structure which he describes invisible.

Dr. Pigott's views came before the Royal Microscopical Society at their meeting in last November, when a paper from him was read on "High Power Definition," and which was published in the December number of the "Monthly Microscopical Journal." In that paper the following passage occurs, in which, commending the skill displayed in the construction of deep objectives, he says, "Yet in the best glasses there is a certain residuary aberration (chiefly spherical) which obscures the clear definition, under a power of 1000, of a string of beads less than 80,000 to the inch, while a

visual angle of 6″ would represent an object whose diameter in the field of a microscope magnifying 1000 linear must be 1—3,460,000th of an inch, or less than the 3,000,000th part of an inch. From this we can form some idea of the exceedingly minute character of objective aberration: even for a good one-eighth object-glass it does not exceed the fifty-thousandth of an inch." In the plate illustrating this paper, Fig. 9 is a drawing of the beaded structure discovered in the Podura by Dr. Pigott, on which more will be said. Let it suffice now to note that the beads are quite big enough for us to expect to see them with such glasses as we possess. Dr. Pigott regards them as about 1—150,000th of an inch in diameter.

Now, the first objection to his theory, that the spherical aberration of ordinary good glasses obscured these beads, which I felt, was, that the alleged aberration did not prevent such glasses showing similar small objects, such as the dots on the most vexatious diatoms, the structure of minute bacteriums, etc., etc. As others may feel this objection, let us logically see exactly what it is worth. It seems to show that the alleged spherical aberration was not the *only* cause of the invisibility of the beads, though it *might* clearly be the determining cause. The visibility of minute beads will depend partly on their position, and partly on their structure and special action on light, and partly—I might say greatly—on the method of illumination employed. It is plain that minute objects, more or less transparent, arranged in successive layers, covered by membranes, and exerting peculiar refractive and reflective power on light, might be quite invisible, from those conditions; or they might be nearly invisible with a particular objective; or, they might be invisible with what we might call a good glass, and become visible with one a little better.

I will detail the steps I took in this investigation, because others may like to follow or vary them. First, I set to work with a Beck's one-twentieth, and careful illumination with Reade's prism, and with a single radial slot stop and Ross's four-tenths condenser. By getting the light from one direction only to fall at the best angle (somewhat less than a right angle to the lines of marking), I soon saw *some* dots, as Mr. Reade had done before me; but I could not make out anything like an upper and under series, as described by Dr. Pigott in the test Podura.

Presuming that scales of Lepidoptera were likely to be formed according to a uniform plan, I looked at a variety of large and easier scales than those of the Poduridæ, and by employing

unilateral light, I soon came to the conclusion that the principle on which certain well-known, but imperfectly drawn and described, markings were formed, was by the deposition of some soft material between the membranes of the scales, and in the hollows of their folds, in little drops or dots. In many cases the resolution of such markings into distinct dots or beads was not difficult. In other cases the beads seemed pressed close together and flattened; in others they looked confluent, and in still others I could not detect any beaded structure at all.

Some will say how are we to know that such scales are composed of *two* membranes, and that one or both is wrinkled, corrugated, or folded, whichever term may be preferred. Let us at once see what can be done to reply to these very proper and judicious doubts. I will go back to a paper in the third volume of the "Transactions of the Microscopical Society of London," by Mr. Warren De La Rue, on the Markings of the Scales of *Amathusia Horsfieldii*. The markings were discovered by Mr. De La Rue, using a one-twelfth objective of 110° aperture, and I presume at about the date of the paper, 1848. What Mr. De La Rue saw and figured is copied in the plate illustrating this paper, Fig. 8, which represents a sufficient portion of the scale to show the beads properly. The entire scale is figured in the original illustration.

Mr. De La Rue alluded to Dr. Bowerbank's paper in the "Entomological Magazine"* as follows:—"This gentleman, after minutely describing the methods adopted to dissect out and exhibit the structure of the scales, came to the conclusion that they consist of three distinct layers, viz., the upper membrane, which contains the colouring matter; the striæ, which constitute the frame; the under membrane, which is nearly colourless; and finally the ribs, which are in reality tubes." Probably Dr. Bowerbank would at this date modify these views. They seem to me only partially correct. Mr. De La Rue, coming to his own observations, said, "the cross striæ, when viewed with a one-twelfth of 110° aperture, and illuminated with a quarter of 60°, used as an achromatic condenser, and adjusted well to focus, came out under a power of 825 diameters in beaded lines, on which protuberances were distinctly seen; these latter, when focussed at their summits, appeared as brown dots. The longitudinal striæ, under the same circumstances, have a somewhat corrugated appearance, but not so marked, and at the upper surface similar dots." In another passage, speaking of the cross striæ, he said, "I have convinced myself by careful and

* Vol. v., p. 300.

repeated examinations that the striæ themselves are really beaded. . . . . The number of beads in the cross striæ of the Amathusia are from two to four: they are not globular, but, on the contrary, vary much in shape, or are connected together by a broad neck."

Microscopists, whose collections contain a slide of this scale, may like, with present means, to compare their own observations with Mr. De La Rue's figure and description. Without regarding it as entirely correct, it seems to us an important step towards the recognition of a beaded structure in scales, the markings of which had been previously very imperfectly seen.

Dr. Carpenter, apparently citing M. Bern. Deschamps, "Sur l'Organisation des Ailes de Lepidoptères" ("Ann. des Sci. Nat. Ser. 2. Zool.," tome iii.), says, in his work on the "Microscope," "Each scale seems to be composed of two superficial coloured laminæ inclosing a central lamina of structureless membrane, the surface of which is highly polished, and acts as a foil to increase this brilliancy by reflecting back the light which passes through them—an arrangement that may often be discovered in scales that have lost a portion of their superficial layer by some accidental injury."

I have never seen any reason to believe in this "central lamina." I doubt there being *three* layers in Lepidoptera scales. Dr. Carpenter's figure of the *Morpho Menelaus* does not exhibit any distinct resolution of the markings into rows of dots; but he speaks of the strong longitudinal striæ as apparently due to "ribbed elevations of the superficial layer." "There is also," he adds, "a transverse striation which cannot be seen at all with an inferior objective, becomes very decided with a good objective of medium focus, but is found, when submitted to the test of a high power and achromatic condenser, to depend upon a sort of beaded subdivision of the longitudinal ribs; the transverse striæ that may be seen *between* the ribs, being produced by the beading of the ribs on the other surface of the scale." This observation is very important, though I do not agree to the term *rib*, nor do I think constrictions or beadings of *ribs* are the causes of the dots.

The "Micrographical Journal" speaks of the striæ on insect scales as in some cases composed of "bead-like dots," and of the longitudinal striæ as elevations or ridges of the surface, probably representing the folds of the upper layer or membrane of the scale." The information on this subject, supplied by this generally valuable work, is meagre and unsatisfactory.

Mr. Gosse, in his "Evenings with the Microscope," describing the scale of the Bristle Tail (*Machilis*), speaks of the longitudinal lines as "thickened ribs," which "seem to be made by elevations of the membrane both above and below." He adds, "between the ribs, on a larger scale, there are a number of very delicate cross lines, which are probably regular wrinklings of the depressed surface." Speaking of the Lepisma scale, he notices that "the ribs on the two surfaces diverge at a different angle, those of the upper surfaces being the more divergent, divaricating from the foot-stalk, while those of the lower membrane are coarser, more nearly parallel, their bones ranging along the hind edge of the scale. The effect of the intersection of the sets of lines at so acute an angle is to convey the optical impression that the scale is covered with short irregular dashes." Another impression is that of rows of false dots, which always appear when two very narrow cylinders, or any similar formation are crossed at right angles, one set being placed just over the other.

M. Arthur Chevalier, in his "Etudiant Micrographe" (1864), speaks of the *plumules* of the *Pieris rapæ* as a test-object. He says, "With an amplification of 300 times, we distinguish the granulated arrangement which gives the appearance of a chaplet, with a certain interval between the beads. We recognize the goodness of the instrument by the sharpness of the granulations, and *sometimes we can count some of them.*" The italics are the author's. He also mentions the plumules of *Pieris brassicæ* as having similar granulations, "and constituting *a very difficult test-object.*" It is really an easy one.

Thus very little appears—that I can discover—to have been done in the way of recognizing what I think will prove to be the fact, that throughout the scales of the Lepidoptera there is a tendency to formations which may be described as rows of beads, arising from the internal surface of the upper or lower membranes, or from both.

The scales of these insects must, I suppose, be considered to be dermal appendages, and generally conforming to skin formation. Quekett, in his "Lectures on Histology," observes that "Entomologists are now in the habit of describing the skin of an insect as consisting of three layers: viz.,—an *epidermis, rete mucosum*, and *corium*. The first two are exceedingly thin. The epidermis is described as being thin and structureless. Mr. Lowne, in his valuable monograph on the blow-fly, properly remarks that this so-called *epidermis* does not resemble the deciduous epidermis of the vertebrates.

The membranes of the wings of insects, and of their scales, are, I suppose, of the same nature as this outer insect skin, and may perhaps be regarded as its expansions and prolongations.

As I see such scales, I am led to believe in an upper and under layer, and in deposits of matter coming from one or both, and lying between the two. The so-called "ribs," etc., of butterfly scales, seem to me only corrugations or wrinkles; and the beads, more or less distinct, or coalescent, as the case may be, I take to be formed by exudations, in drops, from the membranes, consolidating, so far as they do consolidate, in a definite form. It is easy to find on the same scale, and frequently on a single scale, all varieties from distinct and distant beads, to approximate beads, and, finally, confluent ones—at least so I see them; but all *difficult seeing* is in some suspense through Dr. Pigott's researches. One of the best proofs that I have met with that the scales consist of *two* membranes is in a slide of Lepisma scale I purchased from Dr. S. P. Woodward's collection, in which one of the supposed membranes, or, at any rate, one surface, has been partially removed. This is figured in the Plate (Fig. 1). I cannot think it probable that the mere splitting of one membrane would have yielded this result. The rod-like "ribs"—a beaded structure—of the *lower* membrane (the upper one in the slide) are broken off, and the *folds* (as I see them), running diagonally of the upper membrane, with its under surface thus uncovered, are very distinct. We can easily appreciate Mr. Gosse's remarks from scales in this state.

It frequently happens that the slanting wrinkles of the upper scale seen through the perpendicular wrinkles and markings of the under scale (usually uppermost in slides) gives a twisted *barley-sugar-stick aspect*, as shown in Fig. 2. Those who are too learned for anything so simple as a comparison with barley-sugar-stick, may call this appearance "cylindro-gyrate," which will sound very fine.

On looking through a series of Lepisma scales, the extent of resolution into beads will be found to vary very considerably. Some of the so-called ribs seem all dots, or beads, while others are very obstinate in resisting even approximate resolution. The corrugations of the upper membrane vary very much: sometimes making, as in Fig. 1, tolerably wide plaits, and at others coming much closer together. I have not detected any beads in this membrane in the cases in which it is uncovered by the removal of the other membrane, but as I do not know under what conditions that removal

took place, I do not decidedly infer that the upper membrane makes no beads.

If any one will look through scales of that magnificent butterfly, the *Morpho Menelaus,* and illuminate with unilateral light, there will be no difficulty, with powers of from 500 to 900, in seeing that a great many of the "ribs" are easily resolved into rows of beads more or less round, and more or less approximate. The variety is very considerable, as in nearly every kind of scale I have studied. Some of the appearances of *M. Menelaus* are shown in Fig. 3.

I now take one of a common sort of butterfly scale, *Pieris oleracea,* which came from Canada, but I am told is just like English specimens. Not only do scales of different *shapes* vary in minute markings, but those of the same shape vary from each other, and on the same scale different parts vary. This is a pretty constant rule. In the scale of *P. oleracea* before me, the appearance is that of broad longitudinal bands, and when properly illuminated, they are found to be *crossed* by rows of beads, not very regular in either size or position. They are shown in Fig. 4.

I now come to the Poduridæ, and I have to express my thanks to Mr. McIntire for several specimens. In *Petrobius maritimus,* Fig. 7, the beading resembles that of the Pieris just mentioned. What appear as solid ribs with one obliquity of illumination come out as rows of beads in another. I take this to be a case of folds or wrinkles, with beaded structures beneath. Fig. 5 shows the beads of *Degeeria domestica;* Fig. 6 those of *Maccrotoma major.* In the last scales it is easy to show the longitudinal markings as rows of beads nicely rounded, and if the power is sufficient, between each *dark* row on the surface nearest the eye will be seen a lighter row on the upper surface of the membrane which lies beneath. In *Templetonia nitida* I have not got beyond a *suspicion* of beading, but I have little doubt it exists. When Mr. McIntire wrote his paper, which will be found in the "Monthly Microscopical Journal" for Jan. 7, 1870, he had not paid sufficient attention to these beaded aspects, and I believe had only partially seen them. I showed him several on the slides he was kind enough to bring to me, and he has also seen them at the house of Dr. Pigott. The appearances figured by him and by others are correct, *under circumstances;* and before arriving at final conclusions, we are bound to take into consideration all the aspects which these objects present, under conditions likely to afford true indications of what exists.

I have not succeeded in showing the beads on the orthodox test

scale, commonly called "Podura scale," but which systematists name *Lepidocyrtus curvicollis*. *Some* bead-like elevations may be easily seen by employing unilateral light and very high powers from one-eight upwards, but Dr. Pigott brings out the appearances exhibited in Fig. 9.

Before seeing Dr. Pigott's operations, which he kindly invited me to witness, I thought it desirable to go through the preceding investigations, and they left me no excuse for doubting the reality of what he displayed; and the accuracy of his methods were substantiated by the fact that it *improved,* without materially changing the appearance of that well-known object, the *Pleurosigma formosum,* as shown by a fine Powell and Lealand immersion lens.

Dr. Pigott's mathematical researches will come before the Royal Society, and I understand, that from the care he has taken, there is little doubt of their complete accceptance by those who are capable of following this sort of investigation. Without detracting from his discoveries, I may venture to hope that a simpler and easier method than he now employs may be found out. It would obviously be well, if possible, that each object-glass should carry its own means of correcting its own aberrations. As exactly what Dr. Pigott does to "balance the uncompensated residuary aberrations" of ordinary glasses will shortly be published, I will say no more now on this matter, but record my decided opinion that opticians will make a very great mistake if they do not take the earliest opportunity of studying his researches, with a view to give practical effect to them in their future work.

The subjoined extract from Dr. Pigott's paper ("Monthly Mic. Jour.") will show what he sees:—"A. Battledore scales of azure blue. The whole surface is beaded over; the large beads, seen with a half-inch, are formed of a mass of strings of beads, crossing and recrossing.

"B. Fine, transparent, and smallest striated scale of azure blue. The upper ribs appear as distinct, ruby-coloured beading, between and beneath which are seen, *partly obscured,* longitudinal rows parallel to and immediately behind the upper set.

"C. The translucent ribbing of *Lepisma saccharina* is formed of regular beads; and beneath them and radiating from the *quill,* are lines of smaller beads crossing the upper set in straight lines. I see these yellow green, while the upper set are brownish red.

"D. By gas light I observed rows of red spherical beads, placed upon the surface of the test-object marked by the preparer of the scale, *S. Hippocampus,* alternating with yellow-green rows, some-

what encroached upon by the upper sets, all running parallel to the axis of the scale.

"E. The surface of metals and alloys, with a power of 1000 diameters, shows, under reflected light, particles apparently spherical, agglomerated together with dark lines separating the particles."

Another passage is well worth attention, because it somewhat contradicts ordinary opinions. "In examining striated bodies, longitudinal bands glisten with a ruby tint upon a green or yellowish green ground. The bands appear like pellucid semitransparent cylindrical ribs, and the flashing of their bodies with a ruby glow is a signal in my experience that the aberration approaches its minimum." Microscopists will recognise the coincidence of these statements with the action of Powell and Lealand's glasses, which often give an amount of colour that I, for one, have taken for a defect. Mr. Wray—who deserves to be much better known—corrects his glasses upon a similar principle. I do not venture to affirm that Dr. Pigott is quite right, but it is not at all unlikely that when minute beads of a refracting substance, or their films, receive light at the angle best for the exhibition of the structure in question, the proper optical effects may be the splendid tints which many of us have assigned to imperfections of chromatic correction. Showing an object free from colour is not necessarily a proof of the accuracy of the corrections of a glass. The inquiry arises whether or not there is colour to be seen. In soap-bubble films we have a popular illustration of a colourless film exhibiting rainbow hues, because the reflexions of light from its two surfaces—internal and external—lead to the interferences of rays by which colour is produced. If we had a pair of spectacles which prevented our seeing these colours we should not praise their accuracy; and, before we condemn a glass for showing colour when films and minute beads are in the field, we must consider what actions upon light really occur.

I made my investigations as detailed in this paper with a fine one-fifth of Beck's, and Ross's C and D eye-pieces, when the covering glass on my slides was too thick to permit the employment of a higher objective. Upon the Poduridæ I used Beck's one-twentieth, with A, B, and C eye-pieces, usually the B. For illumination I used the Read prism with some satisfaction, but I preferred Ross's four-tenths condenser with one radial slot, and an aperture of from seventy to ninety, and in some cases one hundred and nine degrees. To avoid fog I found it advisable to adjust the condenser by using its optical portion as an object glass, and looking with it

at a slide of the scales turned upside down. As soon as I had got the best adjustment for thickness of the glass, etc., I placed it in its proper position.

It must be observed that when the beads are distinctly seen on such of the Poduridæ as I have resolved, they may be made to vanish (in most cases), and another appearance, that of wrinkles, produced by rotating the condenser a few degrees and changing the angle at which the light strikes the object. With the same corrections and the same sort of illumination, all these aspects should be taken into due account, and likewise those which result from other modes of illumination. It is only by combining *all* the appearances which seem to give real information, that we can expect to arrive at a true conception of structure.

ON THE MULTIPLE TAIL OF THE GREAT COMET OF 1744.

BY J. R. HIND, F.R.S.,

Corresponding Member of the Institute of France, etc.

Everyone who has studied the history of comets will be aware that by far the finest of the eighteenth century was the one discovered by Klinkenberg, at Harlem, on December 9, 1743, and by Loys de Cheseaux, at Lausanne on the 13th. But, according to the convenient method now universally adopted of assigning the comet to the year in which the perhelion occurs, distinguished as the great comet of 1744. In February, in that year, its brilliancy had become very remarakble. On the 10th it was almost equal to Vega and Rigel, but less bright than Sirius. On the 13th its light was between that of Vega and Sirius; and the same on the 15th, when the length of the tail was from 17° to 18°. It was observed at noonday on the meridian at Shirburn Castle, the seat of the Earl of Macclesfield, on February 28 and 29, and by Bradley on the 29th; while Zanotti and Matheucci saw it at Bologna on seven days in full daylight. A noonday observation was also taken at Verona at the observatory of Count Massaei on February 29. But the most remarkable characteristic of the appearance of this fine comet, was the multiple tail exhibited a week after the perihelion passage, the accuracy of which observation has, until very recently, rested upon the sole authority of Loys de Cheseaux. His description of the phenomenon is con-

tained in a special treatise upon the comet, entitled, "Traité de la Comète qui a paru en Déc. 1743, etc. Lausanne et Geneve, 1744." This work has now become very rare, but I subjoin a translation of p. 158, et seq., which relates to the multiple tail.

"The sky was wholly covered from the 1st of March until the 7th; on this day it cleared and gave us some hope of seeing the tail. I had prepared myself to see it under the aspect I had surmised on the 14th. I descended with a friend at 4 h. a.m. into the garden, from which the east was open. This friend walked first and surprised me much by saying that instead of two tails he saw five. I could not believe it, when, having passed some buildings which had hidden the east from me, I discovered in reality five great tails in the form of white rays, which raised themselves, some more, others less, obliquely to the horizon, to an altitude of 22°, and occupying as large an amplitude. These rays were about 4° in breadth, but contracted a little towards the horizon. Their borders were very distinct and rectilinear, each of them was composed of three bands; that in the middle was the more obscure, and twice as broad as those of the borders. These were precisely of the colour of the brightest regions of the Via Lactea, which are between Antinous and Sagittarius, and Opiuchus and Scorpio. Between each two rays it was as dark as the rest of the sky, still in their lower part was a light like that of the extremity of these rays, as though it had been the extremity of other shorter streamers. Besides these five tails bordered with white bands, there was a sixth, much shorter, in which no bands could be remarked, perhaps because it was so low. This sixth, joined to the ten bands the brightest of the others, formed the appearance of eleven rays."

M. Cheseaux then gives the positions of the extremities of the south branch of the tail, of that of the fourth, and of the superior extremity of the left band. They are expressed in longitude and latitude.

		Long.	Lat.
Southern tail	.	307·55	+ 9° 0′
Fourth tail	.	319·55	+34 15
Left-hand tail	.	335·45	+34 0

Cheseaux then remarks that the phenomenon followed perfectly the motion of the fixed stars, with regard to which it appeared quite motionless. Its greatest brightness was at about 4 a.m. At Lausanne it was seen by eighteen persons, and by several at Berne; but on account of unfavourable weather, Cheseaux adds, it was not observed at Geneva nor in Paris. He then gives reasons

for concluding that the phenomenon was really an astronomical one, and connected with the comet. During the two nights it was witnessed, the sky was very transparent, not the smallest cloud nor the least mist being present, and it was especially remarkable that the rays converged upon a point which must have been almost the position of the comet's nucleus, then below the horizon.

These observations of Loys de Cheseaux have found mention in most of our treatises on astronomy; but doubts have frequently been expressed as to the real connection of the streamers with the comet,* notwithstanding the somewhat cogent reasons advanced in favour of this view by Cheseaux, as above noticed. Thanks to Dr. Winnecke, we are now in possession of corroborative and, indeed, conclusive evidence that at the time in question the comet did exhibit a multiple tail. It is known that the French astronomer, Delisle, made a journey to St. Petersburg in the years 1726—1747. Materials, as astronomical observations, etc., were left by him, which are now in the possession of the Imperial Observatory at Pulkova, the non-publication of which at a timely epoch Dr. Winnecke deplores as a great loss to science. Amongst Delisle's manuscripts, are observations of the great comet of 1744, taken in St. Petersburg, from the middle of January to the end of the first week in March. Under date "the night of the 6th to 7th of March," we have the following:—

"Clouds had prevented me from observing the comet in the morning, since February the 29th, but the sky having cleared for the first time on the morning of the 6th, at the hour and in the direction of the rising of the comet, and of the sun, that is to say, in the east, I looked from 4h. until past 5h., if I could not see the comet which I was unable to do; but I remarked many luminous trains in form of tails of a comet, which rose above the horizon, directed from the mouth of Pegasus and of the Little Horse, towards the Swan; they were 15° to 20° in length. I did not pay it great attention this morning (the 6th), on account of some clouds which were in the neighbourhood, having regarded these appearances as aerial phenomena composing a kind of Aurora Borealis; but to-day, 7th of March, in the morning, these appearances being again presented in a very clear sky, I thought it proper to pay them more attention; I remarked four; of which the most distinct persisted,

* Admiral Smyth ("Cycle of Celestial Objects, i, p. 218,") contents himself with observing, "The well-known drawing of this phenomenon by M. Chéseaux, though honoured with the adoption of Delambre, bears internal evidence of a difference of opinion between nature and the artist."

more than an hour, in the situation marked on the figure with regard to the star ϵ in the mouth of Pegasus, and the small unformed star e, which is between the mouth of Pegasus and the southern wing of Cygnus. The phenomenon continued from 4h., when I rose and began to perceive it, until the strong twilight caused it to disappear a little after 5h."

On the mornings of the 8th and 9th the sky was covered, but on the very clear morning of the 18th, nothing could be seen of these tails; Dr. Winnecke points out that two of the streamers were observed in common by Cheseaux and Delisle, though the agreement of position is not quite exact, seeing that they were observed on different mornings at Lausanne and St. Petersburg. The two easterly St. Petersburg branches were not seen by Cheseaux, being too near his horizon, and for a similar reason Delisle did not detect the two westerly ones, remarked at Lausanne.

It may not be out of place here to append a few particulars given by Delisle, regarding the appearance of the comet, which, so far as I am aware, are as yet only published in Dr. Winnecke's paper—"Melanges Mathematiques et Astronomiques tirés du Bulletin de l'Académie Impériale des Sciences de St. Pétersburg," tome iii. p. 503, et seq.

"January 18th. The comet appeared as bright as Algenib, and the star in the head of Andromeda; the direction of the tail was almost parallel to that of the stars marked on Flamsteed's chart χ and u, and the length was equal to the distance between them, or 2° 22′. Position angle of tail=49°.

"January 24th. It appeared brighter than the star in the extremity of the wing of Pegasus (Algenib), or than that in the head of Andromeda, so that it approached a star of the first magnitude in brilliancy, but was larger.

"February 4th. It was larger than stars of the first magnitude, but not so bright as Sirius or α Lyræ. The tail was 10° long; its position angle 50°.

"February 5th. The tail was about 17° in length, but it was very difficult to judge of its termination, owing to the faint light of the extremity.

"February 7th. The tail extended to ϵ Andromedæ, and was therefore about 17½° in length. Position-angle of tail 46°, but uncertain.

"February 10th. It was almost equal to Vega and Rigel, but less than Sirius; the tail, which was broad, appeared divided into

two branches of unequal length, the one 12° and the other, which extended to ν Andromedæ, about 7°; its breadth at this star $1\frac{1}{2}$°.

"February 11th. Comet very bright, equalled, or even surpassed Venus, but was inferior to Sirius. The tail longer than yesterday and very broad; length $17\frac{1}{2}$°; position-angle of longest tail 40°.

"February 13th. The light of the comet again between that of Vega and and of Sirius. Position-angle of tail 43°.

"February 15th. Tail from 17° to 18°. Comet's brightness as on 13th.

"February 18th. The tail was longer on the right than on the left side; on the right it extended to the stars o, ρ, σ Andromedæ, and was nearly 26° in length. On the left side it was somewhat curved.

"On the 11th of February the comet's distance from the sun was 0·5308, and from the earth 0·9108, whence the apparent length of tail ($17\frac{1}{2}$°) corresponds to a true length of at least twenty-eight millions of miles.

"On March 7th when the comet exhibited the multiple tail, the average length of the branches appears to have been about 42°. At this time the distance from the sun was 0·3136, and from the earth 1·0171; giving a true length of one hundred and seven millions of miles, on the assumption that the tail was a prolongation of the radius-vector, but as it was then much curved the actual length of the arched tail was of course greater."

In the year 1843 I reduced the observations of this comet taken by Bradley, Maraldi, Le Monnier, and those at Oxford, with all the precision then attainable; the results were published by the late Professor Schumacher in the "Astronomische Nachrichten," Nos. 633 and 634. At that time I had not had leisure to complete the investigation by a new determination of the orbit; I have since satisfied myself that it approached very closely to a parabola, and that if elliptic at all, it will be a very remote posterity indeed that will be interested in its return. It is by no means improbable that the appearance of this splendid comet in 1743—44 constituted its first visit to these parts of the universe.

The work of Loys de Cheseaux referred to above, has become, as already remarked, very scarce, but a copy exists in the library of the Royal Astronomical Society, which is now particularly rich in old astronomical works, chiefly through the admirable administration of the Turnor fund.

THE PROGRESS OF THE MONT CENIS TUNNEL.

BY M. CAZIN.

Translated by Townshend M. Hall, F.G.S., etc.

At one of the last meetings of the Scientific Association of France, held at the Imperial Observatory, M. Cazin presented a report of his visit to the works now in progress on the Italian side of the mountain; where the laborious task of piercing the tunnel is further advanced than it is on the French side. As this report appears in the last number of the "Revue des cours scientifiques," we are enabled to give our readers some idea of the state of the works at the present moment.

If we follow M. Cazin in his interesting visit, and transport ourselves with him to the entrance of the tunnel, we should descend by a ladder of four hundred and fifty-eight rounds, on either side of which run pipes containing compressed air, and we should then find ourselves at the mouth of a vast excavation, into which the eye attempts in vain to penetrate. Not a sound is to be heard, not a glimmer of light is to be seen, although there are probably upwards of two hundred and forty workmen, and forty horses, employed by the light of three hundred lamps. But as they are situated at a distance of 13,123 feet from us, neither the sound nor the light can reach as far as the entrance of the gallery. The noise caused by an electric bell is, indeed, our only indication of the presence of living beings at the extreme end of the dark abyss.

Having arrived at the entrance of the tunnel, we are able to form some conception of its shape. Its section is nearly that of a circle, of which the radius is thirteen feet one and a half inches, and the diameter twenty-three feet two inches—this last number representing its size when measured from the level of the rails. Two lines of rails are laid down for the ingress and egress of the trucks, whilst on either side is a foot-path twenty-seven and a half inches in width. Between the two lines runs the pipe which conveys the compressed air, and as the work advances the sides of the tunnel are lined with masonry. At the entrance of the gallery is the large building which contains the machine used for the removal of the vitiated air. This machine is set in motion, not by steam, but by the descent of an enormous body of water, brought down from the mountain. A piston alternately rising and falling by the pressure of the descending water, produces a vacuum which is conducted to the furthest end of the gallery by means of a pipe,

and the suction exerted by this apparatus is so strong and continuous that it is found to exhaust the vitiated air from the workings, at the enormous rate of 48,000 cubic metres per minute.

The compression of the air is carried on by means of an hydraulic machine much resembling the preceding one in its construction, and which is set in motion by the same fall of water. The pipe by which the compressed air penetrates the galleries, runs side by side with that used for the extraction of the foul air. This compressed air is, as we shall presently describe, the mechanical agent employed for the purpose of driving the boring tools against the rock, and thus, by preparing the holes for receiving the gunpowder, to facilitate the blasting of the rock.

As regards the manner in which the compressed air is able to set in action the borers, and to drive them into the rock, we must give, as it deserves, a more minute description, since an instrument of very peculiar construction, termed a "perforator," is employed in the performance of this part of the work. The mechanism of the perforator is as follows:—A boring tool is fixed to a piston working in a cylinder, into which the compressed air may be admitted at pleasure. A valve, working up and down, regulates the admission and discharge of the air, according as the piston is either propelled or withdrawn after the blow of the borer against the rock. A small tank of compressed air placed near the cylinder works by a cogged wheel, which draws with it both the borer and the piston, making them at the same time undergo a partial revolution. The borer, therefore, in driving a hole into the rock, gradually twists itself round like a gimlet. When it has advanced a certain distance it works on a lever, which is connected with the cogged-wheel by a screw, this screw, by turning in a socket, guides and pushes the cylinder before it, and by this arrangement the machine is made both to work into the rock, and to advance itself forward at the same time. Another piece of mechanism allows the workmen to shift the whole apparatus whenever it is necessary.

If we wish to see this machine in action, we must follow M. Cazin in his visit to the workmen at the furthest end of the gallery. After having passed the portion of the tunnel where the sides are already lined with masonry, we arrive at the scaffolding where the work is actually in progress. Here the miners are engaged in piercing the holes in the rock, making use of the tools worked by the compressed air. A wooden platform divides the tunnel into two stages. Placed on the upper stage are the workmen boring holes for the reception of the gunpowder, which, when they have

charged with the powder, they fire by means of a fuse, and then retire to a safe distance. After the explosion has taken place, a valve is opened, and a violent stream of compressed air is let out for the purpose of dispersing the smoke, and purifying the atmosphere. New borings are immediately commenced, and the same process is repeated without intermission.

At this distance the temperature is moderate, and the air clear, but the noise is almost unbearable, for just in front of us are ten borers at work, striking the rock at the rate of 200 times a minute, with a force of 198 lbs. The small gallery is little more than twelve feet wide, with a height of eight feet six inches. The frame which carries the ten perforators runs on two rails, and the construction of it is such that it is capable of piercing one hundred holes, to a depth of from eleven to fifteen inches, in six hours, over a surface of eighty square feet. Another machine mounted on the same frame, allows of its being pushed either forward or backward, whilst a catch serves to keep it stationary on the rails during the work of perforation. In addition to this, another carriage or tender is placed behind the frame, and carries tanks containing water and compressed air. The water is injected by the aid of a flexible tube round each borer in working the holes; this prevents the tools becoming heated, and also removes all the small particles of rock. A pump set in motion by compressed air draws up the water from wells, which are constructed at certain distances, and fills the reservoirs of the tender.

After the holes are bored, they are dried by a jet of air, and a certain number of cartridges are then inserted in the central holes, leaving the remainder empty, in order to give a line of the least resistance.

The perforators, with their frame and tender, are then removed to a distance of thirty-two yards from the face of the rock, whilst the workmen retire to ten times that distance. When the explosion has taken place, it is found to have left a breach in the centre of the rock, and this is subsequently enlarged by introducing cartridges into the remaining side-holes. At the moment the charges are fired, all the air conduits are opened, so that the smoke may be dispersed as soon as possible. When all the mines are sprung, the rubbish is thrown into small trucks, which run on either side of the perforating machine, and then is transferred to ballast waggons, drawn on the railway by horses.

It is thus that the workmen employed in this difficult and complicated task advance little by little; each day upwards of 720

charges are fired, consuming from 485 to 551 lbs. of powder. Every set of explosions affords a rest of about ten minutes, and the gangs of men are relieved three times in the course of the twenty-four hours, so that no workman is employed more than eight hours at a time.

Having witnessed the blasting operations, M. Cazin returned to the entrance of the gallery, and on his way he found an accumulation of smoke just at the spot where the masons were engaged building the arch of the tunnel. This was the point where the two opposing currents of air met each other—the one coming from the bottom of the gallery was being driven out by the emission of compressed air, whilst the other, coming from the entrance of the tunnel, was being driven in by the action of the ventilating machine. When he had passed this point the atmosphere became pure again, and so continued till he arrived at the mouth of the tunnel.

M. Cazin, in the course of his paper, discusses several interesting questions. Amongst these the first is—How is it possible in cutting through such a thickness of mountain, and commencing at both ends, to trace the direction of the tunnel, without having any common point of observation, or any possible communication between the two extremities, by which to level. In 1857, Messrs. Borelli and Capello, two Italian engineers, made the geodetical measurements which were required to solve this problem—a problem, it is scarcely necessary to say, which presented considerable difficulty. They selected for the direction of the future tunnel two straight lines. That on the French side starting from Modane at an elevation of 3943 feet above the sea, and rising with the gradient of one in forty-five. The other line left Bardonnèche on the Italian side at an elevation of 4380 feet, and rose with a slight gradient of 1 in 2000. This direction from Modane to Bardonnèche having been indicated many years previously by M. Médail as the most favourable, and as presenting the least amount of difficulty. The method by which the engineers are able to insure the meeting in the centre of the mountain of two galleries begun on either side requires a few words of explanation. On a slope opposite each end of the tunnel is fixed a glass, the axis of which gives the line or direction of the tunnel. On the highest point of the mountain, 9679 feet above the sea-level, a theodolite is placed, by the aid of which the two lines, with their respective gradients may be connected with each other. It is then easy, by the assistance of landmarks erected on the mountain, to lay down on a plan the axis of each glass, and so obtain the exact direction in which the tunnel is progressing.

These same landmarks are also frequently employed in the course of the works to verify the position of the glasses.

The total length of the tunnel, calculated from all the results of the triangulation, is 12,220 metres, or, in other words, 7 miles 4 furlongs 164 yards and 1 foot. The second question discussed by M. Cazin has reference to the geological composition of the rocks, which have been met with in the course of cutting through the mountain. It is extremely curious to observe how exactly in this instance the predictions of science have been fulfilled. M. Elie de Beaumont on the one hand, and M. Sismonda, the Italian geologist, on the other, had expressed their opinion that, in proceeding from France into Italy, the following rocks would be found.

1. A bed of schist, with anthracite. Thickness, from 1500 to 2000 metres.
2. A bed of very hard quartzite; with a thickness of from 400 to 600 metres.
3. Compact limestone, with gypsum, anhydrite and dolomite; 2000 to 3000 metres.
4. A series of calcarcous schists; from 7000 to 8000 metres in thickness.

According to M. Elie de Beaumont and M. Sismonda, no igneous rock would be encountered, since all the formations in these parts of the Alps, belong to the group of stratified rocks, and they considered that the quartzite would be the only substance presenting any difficulty in piercing through the mountain.

Up to October 1st, 1869, the following rocks had been met with in the construction of the tunnel.

1. The schists, and carboniferous sandstones, containing veins of anthracite. Thickness, 1967 metres, or 6453 feet 6 inches.
2. Quartzites; with a thickness of 381·75 metres, or 1252 feet 6 inches.
3. Beds of gypsum, anhydrite and dolomite; 2355 metres, or 7726 feet 6 inches.
4. The calcareous schists; 1448·75 metres or 4753 feet on the French side, and 5986 metres, or 19,640 feet on the Bardonnèche, or Italian side. The portion which remains to be tunnelled belongs, no doubt, to this same formation.

Thus we find the predictions of science have been fulfilled in as complete a degree as anyone could desire. At Modane, the mineralogical collection visited by M. Cazin, contained specimens of anthracite and pyrite, found in the first bed. Quartz, pyrite, and

talc, from the second. Gypsum and anhydrite in fibrous masses, from the third bed; and rock-salt from the fourth.

Another question answered by M. Cazin has reference to the probable length of time in which the tunnel will be finished. Taking into consideration the activity with which the work is being carried on; considering, also, the nature of the rock which remains to be pierced, and considering the progress which has already been made on either side, M. Cazin says there is every reason to believe that the difficult task of tunnelling beneath the Alps will be completely finished in two years. It is true that there is still much to be done in connecting the two extremities of the tunnel with their respective approaches, and in bringing them to a level. This will necessitate the cutting away of the rock at either end, so as to bring the line up to the mouth, in the form of a curve. But these works enter into the ordinary class of railway operations, and are so far independent of the great tunnel, that when the time arrives, it will be easy to push them on with as much rapidity as may be required.

It is considered by some persons that when the tunnel is completed, there will be a violent current of air sweeping through it, of sufficient strength to cause inconvenience to the passengers. There is, as we have already stated, a considerable gradient in the interior of the tunnel, and on the French side the entrance is no less than 436 feet lower than that on the Italian side. The mean pressure of the atmosphere would, therefore, on the one hand, be greater at Modane than at Bardonnèche, and, on the other, the temperature is less on the French side of the Alps. These causes might certainly produce a current of air rushing from Modane to Bardonnèche, and, regarding its velocity, it is difficult at the present moment, to form any idea; but there is no reason to fear that it will be found to prove any serious obstacle.

Our concluding question is, what will be the cost of a work so gigantic, and so unusual in its character? It is, perhaps, scarcely necessary to say that it will exceed in proportion the cost of an ordinary tunnel. The total expense will be met by the sum of 54 million francs, or £2,160,000, provided it is completed by the 1st of January, 1872. The French and Italian governments have each agreed to contribute one half the cost.

COAL-TAR AND ITS PRODUCTS.

BY EDMUND J. MILLS, D.SC., F.C.S.

THE history of coal-tar and its products is not only interesting as a chemical romance, but as furnishing a striking example of the practical utility of pure or abstract research. Within the memory of many of us, tar was a repulsive nuisance—

Ἀχρεῖον καὶ παράορον δέμας—

which had sometimes to be stealthily removed at night, under apprehension of legal proceedings. It is now, if not the king, certainly the viceroy of manufactures; it has suppressed and created whole branches of industry, and seems still to be unexhausted as a source of products, the extrication of any one of which may affect the prosperity of large sections of labour. I purpose, therefore, to give a brief account of this remarkable body, and of the nature of such of those substances as have been derived from it and are actually the subjects of art utilization. It will be necessary to commence with some considerations as to the nature of coal itself. Coal, as is well known, consists principally of carbon, an element of which the diamond, graphite, and lamp-black are also almost wholly composed. Nor can there be any doubt whatever, that this carbon has been eliminated by some slow process, from vegetable structures. The chemical changes involved in this transformation are not quite so clear as might be desired; but there seems good reason to suppose that they chiefly partake of the nature of what is known in pure chemistry as "condensation." The meaning of this will be evident if we take as an illustration *cellulose*, a substance which abounds in all plants, especially those of rapid growth, and must have been itself principally concerned in the genesis of coal. Let it be assumed that cellulose ($C_6\,H_{10}\,O_5$) resembles most other complex organic bodies possessing alcholic functions, and the following results must ensue on the protracted application of a gentle heat, especially if aided by pressure. The cellulose will *unite with itself*, and at the same time part with the elements of water, $2[C_6\,H_{10}\,O_5]$, becoming $C_{12}\,H_{18}\,O_9$ and losing $H_2\,O$; the same will happen to the body $C_{12}\,H_{18}\,O_9$, which will become $C_{24}\,H_{34}\,O_{17}$; this, in its turn, will be transformed into $C_{48}\,H_{66}\,O_{33}$; and so on. Now let us compare the percentage compo-

sition of cellulose, with which we started, and that of the derivative $C_{48} H_{66} O_{33}$. The numbers are as follows—

	$C_6 H_{10} O_5$	$C_{48} H_{66} O_{33}$
Carbon	44·4	49·2
Hydrogen	6·2	5·7
Oxygen	49·4	45·1
	100·0	100·0

at this, the third stage of the process the gain in carbon is 4·8 per cent, while the loss of hydrogen is 0·5, and of oxygen 4·3 per cent. It is evident, then, that by continuing an action of this kind we should eventually obtain a product, consisting of carbon and a very small quantity of hydrogen; it would undoubtedly be black; and altogether very similar to coal. . The formation, then, of coal can be accounted for without deserting well-known results of theoretical research.

Coal contains, in addition to carbon and hydrogen, small amounts of sulphur, phosphorus, nitrogen, oxygen, iron, and other mineral matters, and most of these have a direct influence on the nature of the tar.

If pure carbon were heated alone, either in a vacuum or in presence of some gas which is without action upon it, nothing more would happen than a change of density one way or the other. When, however, coal is heated under the same circumstances (or in a close vessel, kept as full as possible, such as a gas retort) it loses weight, giving off a mixture of gas and vapour, and leaving a residue which is known as coke. The mixture of gas and vapour, if passed through a series of cold vessels, as is the invariable practice, deposits tar, the quantity of which is smaller as the heat applied to the retort was greater; while the gas passes on and is used for illuminating purposes. It deserves to be mentioned, however, that in the manufacture of coke, the whole of the volatile products are generally permitted to escape; an instance of negligence and bad economy which deserves the severest reprehension.* Coke retains the whole of the purely mineral constituents of coal, and very minute portions of the more volatile bodies above named; of these, however, the sulphur not unfrequently rises to 0·5 per cent—enough to cause the

* Six years ago, Dr. Hofmann stated that some promising experiments had been carried out at Alais (Jury report, International Exhibition, 1862, p. 67), but the coke manufacturers do not seem to have yet made any alteration in their plan.

use of coke as a fuel to be very prejudicial to health, unless there is a strong draught to carry off the products of combustion.

Tar, as has been indicated, is the resultof a process of destructive distillation carried out in iron or clay retorts, which are kept as fully charged as possible, and preserved from the entrance of atmospheric air by some simple contrivance. In the manufacture of gas, it is an object to avoid the formation of tar as much as is practicable; accordingly, a dry coal ought to be selected, and heat should be applied to the retort as rapidly and as strongly as is allowable. But as the mass in the retort does not readily conduct heat, it follows that much of it is necessarily subjected to only a slowly increasing temperature,—a condition which involves the formation of tar. Gas, then, and tar in a state of vapour, leave the exit-tube of the retort together; the latter is separated in a cooling tank, and, when it has acquired sufficient volume, is offered for sale.

What is it that really happens in this distillation?

The careful investigation of a large number of the constituents of tar, which has been made by many different chemists, furnishes a clear and very beautiful answer to this question. Just as the conversion of cellulose into carbon, in which, as has been pointed out, lies the whole secret of coal-formation, is a process of "condensation," that is, of producing a complex from a simple body, according to a known law; so the conversion of coal into gas and tar is a process whereby a complex material is split into a number of much simpler components. Of this we may feel certain, even though the mode of decomposition and simplifying cannot be so exactly formulated as in the previous case. It is interesting, also, to notice that the various chemical products obtained exhibit every grade of complexity,—from hydrogen (H_2), for example, to compounds of even higher order than the crystalline anthracene (C_{14} H_{10}).

The general nature of the distillate can now be deduced from that of the coal itself. While some of the oxygen and hydrogen of the coal must unite to form water, there must also be formed bodies of increasing complexity that are analogous to water. Examples of these are to be found in the alcoholic class, of which phenol ("carbolic acid"), cresol, and phlorol are members. Again, the nitrogen and hydrogen of the raw material combine, on heating, to form ammonia; but ammonias of much importance are also found, exhibiting various grades of intricacy, but all preserving the common function of neutralizing hydric chloride (hydrochloric acid), just as ammonia does. Aniline and pyridine are instances of these. Lastly,

carbon and hydrogen, besides giving rise to their lowest possible compound (marsh-gas, CH_4), under these circumstances, originate at least two converging series of hydro-carbons, all of which closely resemble it. Phenylic hydride (benzol) and capryolic hydride are illustrations of the two groups respectively.

Among the special constituents of tar, a few substances deserve to be noticed as possessing an incidental interest. These are, hydric cyanide (prussic acid), hydric sulphide, or sulphuretted hydrogen (found in combination with ammonia), and hydric acetate (acetic acid). As the quantity of oxygen in coal is generally very small, we cannot expect to meet with a great variety of its compounds in the products of distillation; accordingly, when we have added to the alcoholic bodies previously alluded to, the sulphuric oxide known as sulphurous acid, and carbonic dioxide ("acid") and hydric acetate, the list is probably complete.

When the tank in which the tar has collected is examined, it is found that a rough sort of separation of the ingredients has already taken place, the liquid having divided itself into two masses, or layers, one of which is watery and the other oily. It will be convenient to discuss these, in the first place, apart.

CONSTITUENTS OF THE AQUEOUS LAYER.

The most important constituents of the aqueous layer are the ammonia and ammoniacal salts which it holds in solution. The chief of these are the carbonate, sulphide, and sulphocyanide. In order to utilize the ammonia, the watery liquid is, in one process, pumped into large shallow vessels, and there mixed with excess of hydric chloride. In this manner, all the ammoniacal salts are decomposed, and sal ammoniac, impregnated with a dark colouring matter, settles to the bottom, insoluble in the acid fluid. Meanwhile, much heat is evolved, and sulphuretted hydrogen is given off in not unfrequently dangerous quantities, intoxicating and stupefying the workmen. When the sal ammoniac has thoroughly cooled and settled, it is taken out and dried, or else evaporated to dryness, directly in contact with the whole fluid. In either case the crude dry salt has to be sublimed several times, in pots specially designed for the purpose, before it has entirely lost its colour, and is fit for the market.

It is not, however, always the case that sal ammoniac is desired. In the alum manufacture, for example, ammonia alone is requisite, and is applied in the following way. When the mixture of aluminous earth and oil of vitriol (the starting-point in the preparation of

alum) has been heated to about 110° C., the vapours from crude boiling gas-liquor are passed into it. But as mere ebullition does not extract the whole of the ammonia from the liquor, lime is thrown in at a certain stage of the process, so as to combine with the acid factors of the ammoniacal salts, and thus liberate the whole of the ammonia. Ammonia, oil of vitriol, alumina, and water, form, when combined in certain proportions, the alum of commerce. Weak ammoniacal liquids are exhausted of ammonia by heating them to a high temperature in a closed vessel, and suddenly discharging the compressed vapour into water, or weak oil of vitriol.

The utilization of ammonia in the manner here described has thrown into the market an equivalent quantity of potassic salt that was formerly employed for the same purpose. It seems probable that, up to the year 1851, the whole of the alum manufactured in Europe was potassic alum. With the increasing rise in the price of potassic salts much attention was directed both to cheapening the process of preparation as well as the materials which were required. Now ammonia alum does not differ from the potassic species either in colour, crystalline form, or general applicability. The substitution, therefore, was silently effected; and, to this day, the bulk of the public are ignorant of the very harmless and laudable replacement. Probably the whole of the alum manufactured in England (now more than 300 tons a week) is exclusively the product of the ammonia process.

Were the whole of the ammonia produced annually from coal in London alone to be collected in its perfectly pure and dry condition, the yield would amount to approximately three thousand five hundred tons. If all the ammonia now lost in the coke manufacture were to be utilized, instead of being wasted as at present, it could be sold to the consumers at nearly one-half of its present price.

In addition to ammonia and its salts, the aqueous layer contains a small proportion of the analogues of ammonia to which we have already referred. These are known as "the pyridine series," having been thus named after their first member, pyridine, discovered by Anderson. They do not appear to have been a subject of commercial effort, although there is very good reason to believe that they will be made available as sources of colour. They are all highly stable liquids, of somewhat offensive smell. Their presence can be detected in the ammonia of commerce, to which they impart a trace of their odour, and render sufficiently impure to prevent the employment of that product in researches of delicacy.

THE OILY LAYER.

It is this portion of the tar that possesses so great an interest, whether for the abstract inquirer into chemical laws, the investigator into social causes, or the manufacturer. No better instance, perhaps, could be adduced of a product which has united by one common bond the thoughtful seeker after purely intellectual delights, the pecuniary speculator, and the numberless grades of varying merit that fill the interval between them. Here and there, as we shall see, some guess, or happy conception, or inference has, in a short time, affected the countless interests of thousands of men. The historical reader will remember how, on a sudden inspiration, the field of Salamanca rewarded an illustrious general; yet I dare not consider the consequences of that brilliant engagement as important as single discoveries made in connection with the black, offensive liquid which we have now to consider.

After the separation of the water (which is promoted by maintaining a moderate heat in the tank), the oily layer is pumped into stills of varying size, but capable, on the average, of containing about a ton each. Heat is cautiously applied, and the distillate condensed by passage through a worm immersed in cold water. As the operation proceeds, a gradual change takes place in the nature of the product. At first an oil is obtained which is lighter than water (*naphtha, light oil, spirit*, etc., etc.); next, an oil which is heavier than water (*dead oil*); and, lastly, solid products, such as naphthaline, paraffin, anthracene, and chrysene—at which stage the worm must be removed. If the distillation has not been pushed to its ultimate stage, the residue in the retort is pitch; but if this condition has been exceeded, only carbon remains in the retort.

Oxygenous constituents. The only valuable oxygenous constituent of the oil is phenylic hydrate, or, as it is often termed, "phenol," or "carbolic acid." It is present in considerable quantity in the heavy or dead oil, boiling between 150°—250° C. Instead of obtaining it by the comparatively slow method of rectification, recourse is had to a process depending on what we have termed the alcoholic function of this body.

Phenol, although but sparingly soluble in water, is readily dissolved by an aqueous solution of sodic hydrate (caustic soda), forming a chemical compound therewith. The appropriate fraction of the dead oil is therefore agitated with aqueous sodic hydrate in excess, whereby a watery layer is obtained, which holds all the

phenol, while a layer of neutral oil separates it. The sodic phenol solution can therefore be easily drawn off, when it is treated with some acid body (hydric-chloride, or sulphate) in order to remove the sodium, and set phenol free. The oily phenol is in its turn mechanically removed from the aqueous solution of sodic chloride or sulphate, and subjected to repeated distillation; ultimately it makes its appearance in beautiful white crystals, which melt at about 35° C. Large blocks of it have been several times exhibited.

Phenol has been applied to numerous useful purposes. Its aqueous solution has been used in enormous quantities for washing overcrowded courts and alleys, during the prevalence of epidemics. The same solution, injected into the blood-system of animals suffering from the cattle-plague, apparently acted efficiently as a remedial agent. Fish die when immersed in it, and their bodies dry up without putrefying; and animal substances of almost every kind are preservable from decomposition by its means. Hence, it is invaluable in the dissecting room; and is much prized as a surgical dressing. Albumen is precipitated by it. The virtues of tar-water, formerly so much extolled, were probably due to its containing a little of this substance.

Pure dry phenol attacks the skin and mucous membranes powerfully; and consequently, if administered internally, is a strong poison. It has a peculiar and very characteristic smell, that can hardly be mistaken. It is utilized on a commercial scale for the production of colours, the stability of which appears to be sufficiently satisfactory. Three of these may be briefly alluded to. *Peonine* is a product of the joint action of hydric sulphate and oxalate upon phenol, under the influence of heat, it is rendered stable by digestion with aqueous ammonia. If peonine be boiled with aniline, a blue colour (*phenol blue, azuline*) is formed. When phenol is treated with hydric nitrate (*nitric acid*) a violent reaction occurs, and it is entirely transformed into "*picric acid*," a yellow dye of considerable beauty and great permanence. Like most of the coal-tar colours, it requires no mordant when applied to silk or wool, but attaches itself at once to the fabric. If, therefore, a white tissue composed of silk and cotton, be dipped in a hot solution of picric acid, and afterwards washed, each of its constituents will be readily distinguishable—the cotton by its unaltered appearance, the silk by the yellow hue it has acquired. Picric acid is very crystalline, and but sparingly soluble in water. Its metallic derivatives have of late acquired greater importance. Potassic picrate, for example, has been manufactured for some time past

on a considerable scale. Most readers of The Student will remember the painful catastrophe of the Place de la Sorbonne, in June last, when six persons were killed, others injured, and several houses were much damaged by an explosion of this salt. The trial of the proprietor, M. Fontaine, has but recently occupied the Tribunal Correctionel. A singular fact transpired in the course of the evidence. M. Houzeau had noticed, on the day of the explosion, that the quantity of ozone in the atmosphere of Paris was unusually great. After the accident had occurred, it struck him as not improbable that the fatal detonation might have been due to ozone. Experiment justified his surmise. On placing a few decigrammes of potassic picrate in a flask of ozonized air, a violent explosion took place, and the flask was shattered to pieces.

TELESCOPIC WORK FOR MOONLIGHT EVENINGS.

BY W. R. BIRT, F.R.A.S.

One of the most striking and interesting groups of lunar objects, if not the principal, on the S.W. quadrant of the Moon, is that formed by the three large "rings," Cyrillus, Catharina, and Theophilus. About five days after New Moon, this fine lunar landscape is seen emerging from night, as the Sun rises on the lofty peaks constituting the rings, 16,000 feet of Catharina, and as high as 18,000 feet of Theophilus above the interiors. Webb says, "There is no scene in the least approaching to it existing on the Earth." The view during sunrise upon it will amply repay the observer, who devotes an hour or two to its examination in the terrestrial spring months of the northern hemisphere, when the Moon is generally high in the western heavens. It is a suitable group for telescopes of all apertures, from two inches to twenty-four inches. All the most salient and striking features may be made out with the smallest. The two ancient craters, Cyrillus and Catharina, their lofty rings, the very curious and remarkable valley connecting them with its peculiar features, are contemplated by the beholder with great interest; which is increased by directing the attention to the more recent crater, Theophilus, with its complete ring and remarkably cleft mountain in the interior. Not only is the recent epoch of the production of Theophilus manifest from the completeness of its ring, but also from the very remarkable corrugated continuation of the eastern portion of the

ring of Cyrillus, which appears as if pushed aside by the intrusion of the larger mass. Phillips, who has given a spirited drawing of the group in "Philosophical Transactions," 1868, Plate XVI., says, "The phenomena which appear where Theophilus joins Cyrillus are extremely curious and complicated, not in the least like as if one cone of volcanic eruption had intruded its convex sloping surface within another, but rather as if one great blister had pushed aside another, and then burst, leaving a sort of double folding along the line of junction." With telescopes of three, four, and six inches aperture, the central mountain of Theophilus is a fine object; its quadripartite cleft on the N.W. side, and its apparently steep S.E. slope to the floor indicate a convulsion of no ordinary character, by which the mountain has been torn asunder. Phillips gives three drawings of this mountain—one of the most interesting on the Moon's surface—and says that he "has given much and frequent attention" to it, "for the purpose of ascertaining the form of its much-divided mass, and of discovering whether it contains any cup-formed summits. None were observed among the ten or more bosses which go to make up the rugged mass, elevated about 5000 feet above the central area." The telescope used by the Professor was by Cooke, of six inches aperture; larger instruments, which are now common, may be advantageously employed for scrutinizing this mountain, the central mountain of Cyrillus, and the numerous peaks on the rings of the three large craters.

On the 21st of October, 1868, 6.20 to 7.30 G.M.T., I examined, with the small aperture of 2·75 inches, Phillips's drawing, and particularly noted the aspect of a crater which he has given on the N.W., and at the foot of the exterior slope of Theophilus, of an elliptical form, *with an interior shadow on the S.W.* The illumination was then earlier than in the drawing, the shadow of the W. rim of Theophilus reaching to the W. base of the central mountain. Under this earlier illumination it appeared as a very shallow depression *without interior shadow.* Nothing was seen within but a deeper tint of grey, indicating the interior not only to be very shallow, but of a very gradual slope from the west edge. As this is a phenomenon analogous to many recorded by Schröter, it would be well to observe this particular crater with large instruments, especially near the time of sunrise and sunset, as the shadow is well marked by Phillips.

From five to twelve days after New Moon, the gradations of aspect dependent upon illumination may be interestingly observed, this period being equivalent to the morning and forenoon of the luni-solar day—the fine relief gradually disappears, the peculiar

aspects of the various objects under higher illumination as gradually creep over the landscape, and some of the brighter portions increase in brilliancy as the time of Full Moon approaches. The group is well worthy of the closest inspection under every possible illumination.

SAGO PALMS.

BY SHIRLEY HIBBERD.

(*With Coloured Plate of Cycas Rumiņiana.*)

It is now happily common to see in conservatories examples of the noblest forms of vegetation, where, but a few years since, plants of ephemeral character, and comparatively trivial interest, were considered sufficient for the entertainment of their possessors. Palms, cycads, tree-ferns, yuccas, agaves, and aloes, take the lead in the favour of collectors, and afford ample gratification for an advanced taste in their distinct and peculiarly tropical configurations; while for purposes of study they not only conduct our thoughts to far-off climes, and illustrate many a scene of distant travel and adventure, but carry us back to distant ages, when some of them at least dominated in the vegetation of the world, and made their impress upon ancient strata, and contributed to the formation of the vast beds of fossil fuel which characterize the carboniferous limestone. The "Sago-Palms" may not, perhaps, take precedence amongst these noble conservatory plants that in our chilly clime help us to realize the pictures presented by travellers of the glories of tropical scenery.

> "————Overhead up grew
> Insuperable height of loftiest shade—
> Cedar, and pine, and fir, and branching palm—
> A sylvan scene; and as the ranks ascend,
> Shade above shade, a woody theatre
> Of stateliest view."

But whatever their relative place as compared with the competitors that with them share our fostering and demand our admiration, it is impossible to rank them otherwise than somewhere near the head of the scale; for they combine the grace of the fern with the majesty of the palm, and we have but to see a fine example of the well-known *Cycas revoluta*, to receive an impression that can never perish, while the mind retains its hold on forms of created beauty.

CYCAS RUMPHIANA

By "Sago Palms" is to be understood the great group of gymnospermous plants of which the cycads and their allies are representatives—a group possessing powerful morphological relations, and

ABORTIVE FROND AND NUT OF CYCAS REVOLUTA.

of course a correspondence, within certain limits, in all their biological characteristics.

That the cycads should be esteemed by plant-collectors is

readily accounted for by their beauty. But probably few amateurs who cultivate these noble subjects are fully aware of the wealth they possess. True, the money-value of the plants may be easily determined, but what of their scientific value? Their very place in botanical classification is not easy to determine, the method of their multiplication is but faintly understood, their connection with past conditions of soil and climate only dimly shadowed out by the results of geological inquiry, and as they are rarely cultivated with the skill they demand for their full development, those who possess good collections miss many a lesson the plants might afford them were they tended with all the care they deserve.

One great recommendation of the cycads is their adaptability to the conditions under which plants are ordinarily grown in our conservatories. A considerable proportion of all the known species need for their preservation only abundance of light and protection from frost; hence they associate admirably with the sub-tropical palms, yuccas, and tree-ferns, which, speaking generally, only need a climate a few degrees warmer than that of Britain to be in perfect safety, and hence impose upon the cultivator no great difficulties as to the temperature of the structure in which they are grown. But in this very consideration a most interesting point is involved. Cycads, in common with most of the subjects we have mentioned in connection with them, need generous treatment, and it is only by promoting a vigorous growth, with the aid of a genial temperature and abundance of moisture, that, under ordinary circumstances, they entertain us with the almost unique display of their fructification. Now and then a starved plant, newly introduced, perhaps without a scrap of visible leaf or root, at the first start into life, presents its owner with a cone of flowers or fruit. It would have attained to the same condition, at the same time, if left undisturbed in its native wilds. Like a hyacinth or tulip bulb, it only throws up, on the first impulse of stimulus, after a season of dormancy, the reproductive organs that were already formed in embryo, but concealed from view. When they have been for some years in our care, the case is altered; *then* it rests with the cultivator whether the plant shall become fruitful or not, and liberal treatment alone will produce a condition so much to be desired. This is a consideration of the utmost importance to the cultivators of these noble plants.

The *Cycadaceæ* occupy a distinctly intermediate place in the vegetable kingdom. The trunk is cylindrical, without branches, forming only a terminal bud which never divides; hence the growth

is ever a continuation of the original axis. Herein they resemble palms. The leaves are pinnated, and proceed from the central bud by a process of unrolling. The fruit, also, is borne upon leaves, as will be seen presently. In these particulars they approximate to ferns. But the fruits are sufficiently distinct from those produced by any acrogenous plant; they are large, naked nuts, in some cases larger than walnuts, produced in clusters amongst a kind of depauperated leaves. The male organs of fructification, too, occur in cone-like masses. By these characteristics they appear to claim alliance with the Coniferæ. As for their stems, they consist in part of wood, arranged in concentric circles; but in the centre this arrangement ceases, and the wood is confusedly mixed up with the central pith. Thus we cannot properly class them with either exogens or endogens. Their position is anomalous if determined by structure, as, indeed, it must also be if determined by morphology. They obtain their collective designations of "Sago-Palms" from the abundance of fæcula in their stems, sago being the principal product obtained therefrom.

The geographical distribution and economic uses of this family of plants have been admirably treated of in a paper by Mr. J. R. Jackson, of Kew, in the "Intellectual Observer," vol. v., p. 246.

However noble in aspect, or curious in structure, the interest attaching to these plants culminatesin the mystery which enshrouds their fructification. All the cycads, so far as their mode of fruiting is known, are diœcious—that is to say, the male and female flowers are borne on separate plants. We speak of their "flowers" for the sake of a convenient term; but flowers, in truth, they have none, though far removed from ferns, in the distinct separation of the sexes, and the obviousness of the reproductive organs.

The male inflorescence is in the form of a cone, which, when cut through from top to bottom, presents a distinct stem-like axis, around which the floral organs are arranged in the manner of scales. In or upon these scales we must search for the anthers, and be satisfied if we discover them in what, speaking by comparison, we may describe as an obscure and abortive state of development. These antheriferous scales exude a fluid in place of pollen, and fecundation is effected by the transmission of this fluid to the interior of the so-called nut, which may be more properly described as the female flower. We have before us, while writing, a number of the beautiful vermilion-coloured nuts of *Cycas revoluta*. They are as large as walnuts, oval in form, smooth, and highly polished. On making a vertical section of one, we find at the apex the style,

which has a distinctly stigmatic surface where it opens upwards, the orifices which receive the fecundating fluid being in direct communication with the true ovule, which is situated in the very centre of the nut, embedded in feculent matter. In *Cycas* and *Stangeria* the style may be determined without difficulty; in *Encephalartos* and *Zamia* it is otherwise; though, without doubt, the structure of the female organs in these genera is but a modification of that of the others. The interesting question as to the fertilization of *Encephalartos* and *Zamia* is, how does the fecundating fluid reach the ovules?

Although the several sections of the Cycadaceæ differ considerably in conformation and aspect, and, as hinted above, in biological relations, the life history of one would, of necessity, throw considerable light on the histories of all the rest, and indicate the points of interest more especially deserving the attention of the scientific observer. The best known, and perhaps the most highly ornamental of these plants, are *Cycas revoluta*, *C. circinalis*, *C. Ruminiana*, *Encephalartos cycadifolia*, *E. caffer*, *Dion edule*, and *Zamia Loddigesi*.* The first two are frequently met with in a floriferous state in our plant collections, but very rarely do they obtain the attention they deserve.

While writing this we have in view a grand old female plant of *C. revoluta*, which has fruited many times; but as there never happened to be a male of the same, or, indeed, of an allied species in flower at the same time, its fruits have always been infertile. We will say nothing of its beauty, but will measure the height of the stem, which is no less than six feet, though, owing to its great bulk, it appears to be considerably less. When in fullest vigour of growth the crown of the plant does not rise more than an inch in a year. In its early stages, the growth is far, very far slower than that. We have measured many plants of all the several genera, and in not a few instances failed to detect any increase of height in the course of seven or even ten years. We may roughly guess that our plant is at least three hundred years old, which allows it to have grown from first to last about a third of an inch per annum. Judging from observations of young plants, it is probable that the growth does not average more than a fifth of an inch per annum, and that our six feet stem is scarcely less, perhaps more, than five hundred years old.

* On the subject of the fecundation of Encephalartos and Zamia, see "Illustration Horticole X., misc." p. 39. For the most complete arrangement of the genera and species, see Miquel's "Nieuwe Bijdragen tot de Kennis der Cycadeën," published by Vander Post, Amsterdam.

During twenty years past it has fruited five times, so we may conclude that when mature and carefully cultivated, it produces fruit every four years, but it is highly probable that in its native eastern jungles, it produces fruit every year. When its time to fruit has arrived, we are advertised of the fact by the appearance of an enormous central crown, consisting of an outer ring of narrow buff-coloured leathery fronds, enclosing a great cone, which in due time rises up, and pushes back the outer ring of narrow fronds, which now becomes a kind of frill—the counterpart, perhaps, of a calyx, or involucre. The cone itself consists of an immense number of "altered leaves," or "abortive fronds," to the stems of which the nuts are attached. These leaves are in some respects like the budding horns of fallow deer, they are comb-like in structure, brittle, almost bony in texture, and are covered with a close rough felt-like down of a tawny buff colour. The nuts are so crowded at the base, as to be literally jammed together, hence, such a crown of fruit as we are contemplating, measuring two feet across, must contain a large amount of food, seeing how considerable is the proportion of starchy matter in the substance of the nuts. Most beautiful, indeed, is the contrast of the warm tawny colour of the fronds, and the brilliant vermilion of the nuts, when these have attained maturity. The process of fructification in the female plant, occupies more than twelve months. This fact tends to weaken our conjecture, that in their native wilds they fruit annually; but then the fruiting process may be more quickly accomplished there, as it is well known that female flowers of all kinds continue long in a state of perfection, if not fertilized. When the fruiting is over, evidence of its having occurred remains, for the ring of narrow encircling fronds that acted as calyx, or involucre, remains like a zone of scales on the stem; and thus for fifty, perhaps for a hundred years afterwards, anyone acquainted with the habits of these plants could say for certain that it had fruited; and it would be a foolish thing for the possessor of a plant, to make a boast of its having attained to this interesting condition if it had not; for the stem carries its own family register sufficiently long for one or two generations of men to read what has occurred in their time.

THE MIOCENE FLORA OF SPITZBERGEN.

BY PROFESSOR OSWALD HEER.*

During the summer of 1868, MM. Malmgren, Nordenskiold, and Nauerhoff, members of the Swedish expedition to the North Pole, collected in Bear's Island and Spitzbergen a great quantity of fossil plants, which have been sent to me for examination. The plants belong to two very different epochs, separated by an immense period, the carboniferous and the miocene, and the collections throw fresh light on each formation. At this moment I confine my remarks to the Miocene Flora of Spitzbergen.

Under the name Spitzbergen is comprehended an archipelago situated between 77° and 80½° N.L., the access to which is very difficult. The greater part of the coast to the east is always covered with ice, and the interior of the country is occupied with enormous glaciers, in the midst of which rise mountain peaks, 4000 feet above the sea; but on the west coast the sea, tempered by the Gulf Stream, remains open during the greater part of the year. Numerous fiords run deeply into the land; the glaciers descend to their shores, and continually precipitate into the water immense masses of ice. Such is the case in the fiord called King's Bay (79° N.L.), which is surrounded by huge glaciers, above which gigantic ice-peaks tower into the air. The fiords, Ice Fiord, and Oellensund, are bounded on the north by similar glaciers, while towards the south the snow melts on their banks in the summer, and the earth is covered with a carpet of alpine vegetation. Along these fiords are found rocks of greyish sandstone, resembling *molasse*, and they contain rather important deposits of lignite. Amongst the plants whose debris they have preserved, twenty-three species may be reckoned, which belong equally to the lower miocene formation of Europe, and which indicate to what age we must refer this sandstone deposit.

Another and much more important fossil deposit is situated to the south-west of Ice Fiord, 78° N.L. There uprises a promontory called Cape Starastchin by M. Nordenskiold, in memory of a remarkable man, a Russian reindeer hunter, who lived for fifteen years without interruption in Spitzbergen. According to the calculation of Mr. Grove, the English consul at Hammerfest, he must altogether have passed thirty-nine winters in these inhospitable regions. Thus

* Communicated to the Swiss Academy of Natural Sciences, and published in the "Archives des Sciences," December, 1869.

he seems to have given a formal contradiction to Dr. Mohr, who pretended that no one could winter in Spitzbergen, and that all the attempts to do so had terminated fatally. The Norway whale fishers, who visited the Arctic Crusoe, spoke of him as a little old man, with white hair, and a lively disposition, who passed his time pleasantly during his solitary life in the midst of the glaciers, and who probably slept like a marmot for a good part of the long winter night, lasting in these latitudes about four months. In summer, Cape Starastchin, and the borders of the neighbouring gulf are covered with verdure, on which numerous flocks of reindeer come to browse. In this locality the miocene sandstones, of which I have spoken, are covered by black schists, above which are found the lignites. The plants contained in the sandstones, properly so called, are badly preserved, as its grain is too coarse, and it does not cleave conveniently. On the other hand, the most delicate plants are perfectly preserved in the black schists, which splits readily into thin layers, although they do not show well on the dark surface. On account of the friability of this stone, large pieces cannot be obtained; no doubt it was originally a very fine clay, impregnated with carbonaceous matter, and it passes insensibly into lignites.

M. Nordenskiold and his companions brought from Cape Starastchin about 1000 specimens of fossil plants, among which I recognized 116 species. The deposit to the north of King's Bay (70° Lat.) is by far the poorest in species, yielding only sixteen. A species of equisetum is particularly abundant (*Equis. arcticum*), strongly resembling our *Equis. limosum*. This fact indicates the former existence of a reedy marsh such as we often see.

The total number of species in the different miocene deposits of Spitzbergen amounted to 131, of which 123 are phanerogams, and eight cryptogams; the latter belonging to different kinds of fungi, mosses, algæ, ferns, and equisetaceæ. Among the phanerogams are twenty species of conifers, and thirty-one monocotyledons. This number of conifers is remarkably high; in fact, Germany and Switzerland together have only fifteen, and the total number found in Central Europe is far from equalling the Spitzbergen miocene species. Among these species are five cypresses, five yews (*Taxinées*), one Ephidrine, and seventeen firs (*Abietinæ*). Among the cypresses we must cite prominently two species, *Taxodium distichum*, the deciduous cedar, and *Libocedrus Sabiniana*, Heer, each of which is represented by a multitude of examples.

The elegant branches of the Taxodium are, in particular, very

abundant and perfectly preserved, still bearing male and female cones. Those cones which had arrived at a mature condition had, it is true, not been able to maintain their shape; but their scales and seeds have been perfectly preserved, so that it has been possible to establish, by a minute comparison, that the miocene Taxodium of Spitzbergen is identical in all its organs with *Taxodium distichum,* which is now only found in America, and especially in Georgia and South Carolina, where it grows abundantly in the swamps. The *Libocedrus Sabiniana* is a lost species of great elegance. It is nearly allied to a species of the same genus found on the mountains of Chili; its branches are always opposite, and its seeds bordered with oblique wings. This species, as well as another, which is now rare, *Libocedrus gracilis,* Heer, comes from Eisfiord. A third, belonging to an allied species, *Thuites Ehrenwardii,* was met with at King's Bay, just reaching 70° N. lat.

The Firs (*Abietinæ*) exhibit a very great variety of form. The species belong either to the genus *Pinus,* the only one now existing in Europe, or to that of *Sequoia.* The *S. Langsdorfii,* widely spread at the miocene epoch, and particularly abundant in North Greenland, is wanting in Spitzbergen, and is replaced by a new species, the *S. Nordenskioldi,* Heer, distinguished from it by its branches, cones, and seeds. This tree was very abundant at Spitzbergen, as well as the *Taxodium distichum,* and we can now represent it exactly, thanks to the perfect preservation of its fossil remains. The pines are singularly numerous; except the cedars, and the larches, we find all the principal types of this fine genus. Two species belong to the firs with trigeminal leaves; one among them is identical with *P. montana,* Mill., the other only exists in the fossil state. Amongst the species with trigeminal leaves, we have recognized the *Pinus cycloptera: P. stenoptera,* and *P. macrosperma,* have their leaves grouped five by five. The group of firs (*Abies*) is represented by three species, and amongst them must be noticed our red pine (*P. abies,* L.), of which we have found the seeds, the needles, and one of the scales of a cone. The two other species are extinct, one had small cones and fine seeds like *P. alba,* and the other, *P. Loveni,* Heer, has voluminous cones and stout seeds. Let us also mention *P. Dicksoniana* and *P. Malmgreni,* of which we possess the small seeds, and elegant little leaves, and likewise speak of two species of white fir, represented by seeds and needles.

By the side of these Conifers of well-known forms, we find an altogether special type, which should probably be referred to the family of Taxineæ. It recals on one hand the *Gincho* of Japan, and

on the other approaches the genus Podocarpus. I have been able to distinguish two species, which I have described under the names of *Torellia rigida* and *T. bifida*.

The different species of Conifers I have enumerated are represented in great part by seeds, needles, or leaves, and many have also shown their fruits and their flowers, so that their determination may be regarded as certain.

The data which we possess concerning the monocotyledons are, in contrast with the preceding, much less complete, and some species are somewhat doubtful. We have to enumerate a species of *Cyperus*, with flowers in panicles, a great reed, an iris with large leaves and branching stems (*Iris latifolia*, Heer), a Potamogeton (*P. Nordenskioldii*, Heer), the oval leaves of which floated on the water, a Naias, a *Sparganium* with spherical fruit, and lastly, the fruits of six species of *Carex* (sedge).

Amongst the leafy trees we must cite, in the first place, the poplars, on account of their abundance. The *Populus Richardsoni*, and *P. arctica* are spread all over the Arctic Zone, and they are at Spitzbergen up to King's Bay. These two trees belong exclusively to this zone, while the *P. Zaddachi* is also found in the miocene beds of Samland, near Konigsberg, and also at Alaska. The birches are represented by two species very widely spread elsewhere, *B. prisca*, and *B. macrophylla*, and by a species of alder. The oak family, *Cupuliferæ*, comprise one species of beech and three oaks, two of which, *Quercus Grönlandica* and *Q. platania*, Heer, are distinguished by their great leaves, which must have been the ornaments of the forests of Spitzbergen. We may also mention a plane tree, *Pl. aceroides*, Göppert, and a lime with large leaves, *Tilia Malmgreni*, which bears an analogy to certain species of North America; a service tree, *Sorbus grandifolia*, resembling the *S. Aria* of our mountains; and a walnut, whose nut reminds us of the *Juglans alba* of North America. Bushes were not wanting in the vegetation of Spitzbergen; and we may cite a species of hazel, two species of *Viburnum* (guelder rose), a *Nyssa* (Tupelo), a *Rhamnus* (buckthorn), *Paliurus*, *Prunus* (plum), a *Cratægus* (hawthorn), an *Andromeda*, and a species of ivy.

Among the dicotyledonous herbaceous plants is a *Polygonum* (*P. Ottersianum*, Heer), a *Salsola*, two *Synouthers*, and two *Nénuphars*, of which we possess the rhizomes, the leaves, and the fruits.

All the species enumerated in the preceding pages have their analogues in existing nature; but these last discoveries I have been describing have made us acquainted with many plants which appear

to belong to genera hitherto unrecognized, and whose systematic position is still uncertain. We have already mentioned the genus *Torellia,* and we must add that of *Nordenskioldia,* the analogies of which are still not yet made out.

Let us now take a general survey of this flora, the elements of which we have just enumerated. All the plants lived on the spot, in the marsh or on the solid ground. The strata which enclose them have been found in a fresh-water basin. Nothing can lead us to suppose that this mass of vegetable debris could have been floated to the shores of a miocene sea. There was very probably at Spitzbergen a lake of fresh water, with marshy banks. The Naiads and Sparganiums prospered in its waters; the water-lilies (*Nénuphars*) and *Potamogeton* floated on the surface; the reeds, the sedges, and the iris occupied the marsh, sheltered by a forest of large trees, pines, poplars, birches, alders, and, above all, the deciduous cedar, *Taxodium distichum;* for of all known trees it is best able to live in deep mud (*vase profonde*). The association of the *Sequoia Nordenskioldi,* of *Libocedrus Sabiniana,* and *Taxodium,* permits us to suppose that the two first also prospered in a swamp. Amongst the other trees enumerated, there are species, such as most of the pines, planes, oaks, etc., which like a dry soil; and they probably grew on the mountain slopes not far from the borders of the lake. This may be affirmed with much certainty of the pines, or, among the remains of the various species of this genus that have been preserved, we find no branches, no complete cones, but only needles, isolated scales, and the winged seeds. We may still further conjecture that, at least at the epoch when the black schists were deposited, no river threw its waters into the lake or the swamp; the objects brought to its margin came by the winds, and were very gradually buried in the mud, which accumulated regularly and slowly. After this came a time favourable to the formation of the peat, which we know by the presence of the lignites which covered the black schists, and which are due to the fossilization of this material.

The conclusions which we may draw from this flora, relating to the condition of the soil, are corroborated by the documents which the insects supply, of which we find twenty-two species among the remains of the plants—all, with one exception, belonging to the *Coleoptera,* of which no living species has been found in Spitzbergen. Two of these beetles were aquatic, and two others probably lived on the marsh-plants. Among the rest we may signalize two large species of *Taupins* (mole crickets ?), which doubtless came from the forest.

The investigation we have been able to make of this miocene flora and fauna of Spitzbergen distinctly proves how great must have been the modifications of climate which have taken place since this epoch. Our task is not now to enumerate or discover the causes of these changes; but we will mention one fact. Until last year, only ninety-three species belonging to the existing flora of Spitzbergen were known, although for more than one hundred years these plants have been collected. The Swedish Expedition, to which several botanists were attached, was only able to add a small number of new species to this list. These plants have a character especially Alpine. In Switzerland we must reach a height of 8000 or 9000 feet to meet with an analogous vegetation; while the miocene beds of Spitzbergen, scarcely dug into as yet, have yielded 131 species of plants, constituting a flora which corresponds with that of the plain in the North of Switzerland.

Among the other interesting conclusions which we may draw from an examination of the miocene flora of Spitzbergen, is one on which I wish to linger, because it refers to the great question of the origin of species. There is a general agreement now that each vegetable species proceeded from a single centre, from whence it radiated in the course of ages. Now, Spitzbergen appears to have been the focus of dissemination for the red pine, *Pinus abies*, of *P. montana*, and of *Taxodium distichum*; in fact, we have seen that these three trees existed in Spitzbergen during the lower miocene period. The first two did not live in Europe during the whole of the tertiary period; we seek in vain for them amongst all the European miocene deposits actually known. They are not even found in the miocene deposits of Samland, on the northern coasts of Germany. But, on the other hand, we find in these last deposits abundance of *Pinus laricio*. This species, now spread over the south of Europe, then reached almost the extreme northern frontier of Germany; and, at the same time, *Pinus abies* and *P. montana* prospered in Spitzbergen. At the diluvial epoch, *Pinus laricio* disappeared from North Germany, and found itself driven southwards; whilst *P. abies* and *P. montana* advanced as far as Central Europe. We find these last in all the ligneous schists, at Utznach, Dürnten, Dietzikow, Morschweil, etc., and they are equally encountered on the coast of Norfolk in the Forest Bed. We find them also in the *palafittes*. Still later, *P. montana* withdrew to the mountains, whilst *P. abies* is now the most abundant of the conifers. These two species have totally disappeared from their primitive country since the miocene epoch; but, by way of com-

pensation, they have found a new one in Europe and in Asia. The existing extreme limit northwards is about 10° south of King's Bay, and assuredly this last locality was not even then their northern limit, for they occurred in association with plants which indicate a more southern temperature than they require.

As for *Taxodium distichum*, its northern limit at the miocene epoch was probably at Eisfiord; but it is spread over the whole arctic zone below this latitude. I have received it from Greenland and from Alaska. It was equally diffused throughout Europe, and met with even in Asia. At the quarternary epoch, it had disappeared, not only from the arctic zone, but also from Europe and Asia; and now it is only found in America, where it extends from Delaware to Mexico. We have thus an example of a type essentially American, of which the first traces must be sought for in the arctic zone, where its first centre of diffusion probably existed.

Such facts supply proofs that each vegetable species has its own history, and that every day brings to light documents which may give us certain notions of their development and dissemination.

MOVEMENTS OF CHLOROPHYLL UNDER INFLUENCE OF LIGHT.

BY M. PRILLIEUX.

The following interesting paper by M. Prillieux is translated from "Comptes Rendus," January 3, 1870, and will, no doubt, suggest observation for our microscopic readers to follow out.

It is known that the green matter, or chlorophyll of plants, is composed of globules contained in great numbers in the cells, and many years since a German observer, M. Böhm, announced that he had seen in the Crassula family these globules mass themselves together in the midst of the cells under the direct action of the sun. This observation remained in isolation until a Russian philosopher, M. Famintzin, noticed in the cellules of a moss, of the genus *Mnium*, very decided movements of the chlorophyll globules influenced by light. The discovery of M. Famintzin has been confirmed and extended by his compatriot, M. Boradine. Nevertheless, these curious facts have been received in France with a certain reservation, and have not been observed here.

I am glad now to be able to prove their reality, as the number of drawings I have made with the *camera lucida* of the successive

positions of the chlorophyll globules, can leave no doubt of the facts.

The plant on which I made my observations is the *Funaria hygrometrica*, a moss like the *Mnium* studied by M. Famintzin. These plants are particularly convenient for the purpose of watching what takes places inside the living cells, without altering the normal condition of their life. The leaves are formed of a single layer of cells, and we can place an entire stem of *F. hygrometrica* on the stage of the microscope, and see by transparent illumination what changes occur. When we thus look at a plant which has been previously kept in the dark for one or two days, the leaf presents the aspect of a green network, between the meshes of which the background is clear and transparent. All the grains of chlorophyll rest against the wall of the *lateral* cells, and now are found on the upper or lower walls, which form part of the surface of the leaf, and which I shall call the superficial cell-walls. Such is the aspect of the leaf on leaving the dark, but when it is kept in daylight on the stage of the microscope, lighted up by the mirror, we soon see the globules gliding along, and passing from the lateral to the superficial cell-walls, over which they distribute themselves.

If we distinguish particular globules and draw them with a camera lucida, we see their positions vary, often in less than a quarter of an hour, and to a notable extent, if the condition of the temperature is not too low, and the plant is vigorous. When once the chlorophyll globules arrive at the superficial cell-walls, they stop there, not absolutely immovable, but with very slight change of position, sometimes approaching each other, and sometimes receding. Their general appearance remains the same until darkness comes on, and then the globules abandon the superficial cell-walls; and after a certain time the leaf—instead of exhibiting, as in daylight, a clear space variegated with green dots, distributed over its entire surface—again appears as a green net-work; the chlorophyll globules having resumed their nocturnal condition.

The action of light on the position of the chlorophyll grains may be conveniently studied at night, by the aid of a lamp, which one can light and extinguish at will. I will mention an illustration of this on the 20th December last, at 5 P.M. The plant, which had been kept several hours in the dark, exhibited its chlorophyll globules, ranged along the lateral cell-walls. I then exposed it to the light of a lamp, transmitted through it by the under stage mirror, and by 6h. 30m. many globules had reached the upper surface, even in one

hour the amount of movement was very appreciable, and two globules already occupied the centre of the upper cell-walls. I then put out the lamp, and by 7h. 15m. the globules which had been along the upper wall, had mostly regained their position by the side-walls. At 11h. 30m. P.M., all, without exception, were fixed to the side-walls. I then relit the lamp, and in a few moments, I saw the chlorophyll globules change places, and in a quarter of an hour, many had glided from the side-walls to the upper wall. I sketched their positions at 11h. 55m., at 12h., 12h. 15m., 12h. 30m., and the displacement was then complete; the globules were distributed over the superficial cell-walls: they had resumed their diurnal positions.

Many questions of great physiological interest are connected with these phenomena; now, I wish only to place them on record.

WHENCE COME METEORITES?

FROM a memoir now in course of publication in "Cosmos," we learn that with regard to meteorites (STONES *fallen from the sky*), science has lately made a considerable step.

In examining a mass of meteoric iron found in the Cordillera of Deesa (Chili), M. Stanislas Meunier, Aide-naturaliste of Geology at the Museum of Natural History in Paris, has discovered evidences of an unexpected relationship between this iron and two meteorites fallen at a great distance from Chili, viz., a mass of iron found at Caille (Alpes Maritimes), and a stone which fell at Sétif (Algeria), June 9th, 1867.

The meteorite of Deesa is a mixture of these two rocks: it is composed of iron which is identical with that of Caille, injected in a state of fusion into a stone identical with that of Sétif.

The iron of Deesa is thus evidently an eruptive rock, and it is the first hitherto observed among meteorites.

Besides this, it is demonstrated that the iron of the type of Caille, and the stone of the type of Sétif, have been in mutual connection of stratification upon an unknown globe, and it is the first time that such a connection has been demonstrated.

M. Stanislas Meunier has made the pregnant remark that the meteorites which arrive in these days upon the earth are not of the same mineralogical nature as those which fell in past ages. Formerly iron fell; now stones fall. In the last 118 years there have been

in Europe but three falls of iron, whereas there have been annually, on an average, three falls of stones. The greater number of iron meteorites which exist in our collections—and they are numerous—have fallen on the earth at undetermined epochs; all the meteoric stones are of comparatively recent date. Perhaps even we are justified in saying that stones of a new kind are beginning to arrive, for falls of *carbonaceous meteorites* were unknown before the year 1803, and four have been observed since then.

From this assemblage of facts, M. Stanislas Meunier concludes that meteorites are the fragments of one or more heavenly bodies which, at a period relatively recent (for these waifs are never found except in superficial strata), revolved round the earth, or perhaps round the moon. Having, in the course of ages, finished by losing their own heat, and become penetrated by the cold of space, they have arrived, much sooner than the moon, by reason of their inferior volume, at the last term of the molecular actions which are operating upon our satellite, and which are rendered evident to our eyes by the enormous crevices, the deep fissures, with which it is furrowed.

Split in all directions, they have fallen to ruin, and their fragments, remaining scattered along the orbit, so as to form a circle more or less complete, have at the same time become arranged, according to their density, in zones concentric with the focus of attraction, towards which they are constantly impelled by the resistance of the etherial medium through which they move. The masses nearest to the centre, and which were principally composed of iron, were the first to fall; afterwards came the stones, in which period we now are. Hereafter, perhaps, will arrive meteorites analogous to our crystallized formations, and perhaps even to our stratified beds.

Thus, meteorites, veritable materials of demolition, represent for us the last period of the evolution of planetary bodies. The incandescent orb, the sun, figures at the present day in our system as the sole representative of the primitive state, through which have passed the earth, and all the other bodies which revolve around it; the icy globe, the moon, represents the future which awaits the terrestrial sphere now in all the plenitude of life; and, finally, meteorites show us what becomes of the dead stars, how they are decomposed, and how their materials return into the vortex of life.

We must leave our readers to form their own estimate of the hypotheses put forward. We know as yet too little of the moon to accept the theory which M. Stanislas Meunier adopts, without great reserve.

GEOLOGICAL COLOURS.

BY G. A. LEBOUR, F.R.G.S.,

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Among the various characters which render many minerals and rocks recognizable at sight, none is so obvious and marked as that of colour. We are, however, so accustomed to note at a glance the colour of whatever substance is brought under our observation, that we do so almost mechanically, and are thus apt to forget, or at least to undervalue, the important part played by that character, colour, in the mental diagnosis which we carry away of the body in question, for its future identification.

Almost every imaginable hue is to be seen displayed by some member or other of the mineral world. The most gorgeously painted flowers, the most brilliant plumage of birds, have their counterpart, as far as mere colour and lustre are concerned, in stones and rocks. Daily, the rapid strides which chemistry is now making are giving new colours to commerce and the arts, but still it would be difficult to find one of these tints, the like of which could not be pointed out in some corner or cranny of that vast mineralogical cabinet—our stony Earth.

It is our intention in this paper to draw the reader's attention to some of the more widely spread and more striking of these manifestations of colour among minerals; more especially with regard to those which, forming as they do large masses of the earth's crust, may, perhaps, not inappropriately be termed "Geological minerals."

Let us begin at the red end of the spectrum. We have then to deal with what is perhaps the most prevalent colour of rock-masses, a colour so varied in its gradations that it has been divided by Werner into fourteen distinct shades for mineralogical purposes only. In the arts a much larger number of different reds have been distinguished, as may be seen by looking at the beautiful scale of colours constructed by M. Chevreul for the Imperial manufactory of Gobelins Tapestry in Paris. Our space and the special object we have in view forbid us entering upon the subject in so elaborate a manner, and we must content ourselves with noticing the most prominent cases of red-coloured rocks.

Among the sedimentary formations, entire series of strata in Britain and elsewhere have been named with reference to their most usual or most typical colour; and although this system of nomen-

clature is to be condemned from a purely geological point of view, yet it is admirably suited to our present purpose. Running through any list of stratified systems, we soon perceive a number of deposits with the qualitative *Red* prefixed to them; beginning with the well-known Old Red Sandstone, the beds of which, whether coarse conglomerates, or fine flaggy sandstones, are all more or less tinged with red, varying from the brightest hue to a light-fawn colour, which might perhaps more properly be mentioned under the head "yellow."

As we ascend in the scale of time the next marked set of red rocks we come to is the New Red Sandstone, often so like the Old Red in colour and other external features, that it has frequently, in former days, been mistaken for it, and has thus prevented, for a time, the opening of what have since proved to be most valuable coal-mines.*

Higher up, at the base of the Trias we have more similar-looking reddish sandstones, and above these again we have the Red Clay of Cheshire and some other red beds occurring in connection with the great deposits of rock salt which are themselves often of a dirty reddish hue. Of the same age as these we have the *marnes irisées* or variegated marls of France, among the colours of which red also predominates.

In the Oolites we get fewer red rocks although some are to be met with in the lower members of the division. In the Lower Cretaceous sands, reddish beds are frequent, and at the base of the White Chalk, we have, in the eastern counties, a band of Red Chalk.

Above, in the older tertiaries we have a considerable thickness of mottled clays, the prevailing colour of which is blood red. These brightly coloured beds are conspicuous in Alum Bay, in the Isle of Wight. Then, in the Bagshot beds there are occasionally red sands, as also amid the more recent mottled clays above. Higher still in the series we arrive at the Red Crag, which consists of very variable beds of gravel and sands. This brings us to the summit of the geological scheme of water-formed deposits, but the volcanic and trappean rocks have also plenty of red to show, notwithstanding the dark and gloomy colours which they generally affect.

Thus many basalts, whether augitic or hornblendic, weather into

* The reason is obvious, the New Red Sandstone lying on the top of the Carboniferous rocks, and the Old Red beneath them; and no coal being worked below the Old Red Sandstone.

a red earth. The "Red Ochre" of Antrim is, according to the late Prof. Jukes, nothing but a basaltic ash.

Among the stones used for building and ornamental purposes —which are of course available in large quantities—we have well known red and flesh-coloured granites and porphyries, and among the marbles of various ages we have a great number of different shades of red, as for instance, the clouded light-red of the Mendelato marble, or the splendid blood-red of the Rosso-antico.

When we come to enquire, whence this red, which tinges such a large proportion of what is known to us of the earth's crust, we have but one answer to make—iron. Or rather, the anhydrous peroxide of iron, that substance which we know in its native state as red hæmatite, when the intensity of its colour is such that it appears more black than red. This it is which has coloured all the sandstones, clays, and limestones which we have enumerated above; the same matter as that which gives their brilliant colour to the ruby and the garnet.

There is a brighter mineral red, however, by the side of which "red ochre" is quite dull, this is that of cinnabar or sulphuret of mercury, whence that most striking of colours, vermilion, is derived. This substance is, however, but sparsely disseminated among rocks, and contributes but little to "geological colouring," although in some notable instances the schists which usually contain it have been known to be coloured by it to a considerable extent.

Passing over orange, which as a rock colour can scarcely be said to be distinctive, so apt is it to merge into some shade of red on the one hand, and into yellow on the other, we come to *yellow*, which is second only to red in its universal distribution. It would be tedious to mention every formation in which yellow beds are to be found, as almost every bed of sandstone is yellow in places; even those which we have named above as being characterized by their red colour, have subordinate yellow bands and beds associated with them, or themselves often pass gradually through every shade from one colour to the other. In cases like these it is evident that we have the same colouring matter (the anhydrous peroxide of iron) at work, and that the difference of colour is merely due to the unequal manner in which it has permeated the various portions of the same rock-mass. Thus it has been ascertained that 10 per cent of the red oxide is necessary to colour marbles and schists a *deep* red; however, a very much smaller proportion is sufficient to give fainter shades.

But the true yellow rocks are usually coloured by a nearly allied,

yet different substance, namely, the hydrated peroxide of iron which in its solid and massive form we term brown hæmatite, a dark brown mineral, which when reduced to powder becomes a strong yellow. This is the real colouring matter of typical yellow rocks, and to its presence is due the colour of cairn-gorm and the topaz.

In Italy and in many other volcanic countries native sulphur, the colour of which it is needless to describe here, is sometimes found in such abundance as to attain the rank of a geological colour for the nonce. But even there it can only be considered as one of local importance.

Of green rocks there is an abundance all over the world, and here again we find iron as a powerful colouring agent, this time, however, not as an oxide, as in the case of red and yellow rocks, but as an hydrosilicate of iron. Indeed, among green rocks, silicates play the most prominent part, and especially the silicates of magnesia and alumina. Thus serpentine or ophite and talc are both silicates of magnesia, and are generally distinguished (though not invariably) by their green colour, the former forming enormous masses of rock, both in the new and the old world, and the latter giving its characteristic hue to most of the many rocks, into the composition of which it enters, such as the talcose schists, and the variety of granite termed protogine, or talcose granite. Chlorite, which is a compound of the silicates of magnesia and alumina, is an almost universal mineral, and wherever it finds its way, there do we have its green colour more or less diffused. Many of the slaty rocks of the older formations owe their colour to its presence, and it is to be found in many of the crystalline and eruptive rocks. A chloritous silicate of iron is the colouring agent in the Greensand of the cretaceous period; but in this case, as in some others, where the hydrosilicate of iron is present, the colour sometimes changes into red, by the conversion of the silicate into peroxide of iron.

In chromochre, or oxide of chrome, we have another, but rarer, green producing matter, the colouring power of which is visible in some phorphyries. To this substance is due the beautiful green of the emerald.

We all know the magnificent colour of carbonate of copper in the shape of malachite; the phosphates, arseniates, hydrosilicates, and the chloride of copper are also green, but they can scarcely be numbered among geological pigments, as they occur for the most part in veins only, and not as disseminated minerals. The same may be said of phosphate of lead and arseniate of nickel (annabergite), which are both conspicuous for their green colour.

Blue, our next colour, has most brilliant representatives among "non-geological" minerals, such as that matchless substance chessylite, and the well-known lapis lazuli from which ultramarine is obtained, but as a rock colour it is seldom very marked in character and generally merges into various shades of grey. Thus the Carboniferous Limestone of our country is often blue, but it is difficult to say to what its colour is due. Many shales are bluish, but it is among the clays that blue predominates, though as we have just said, it is in most cases little more than a bluish grey. The London Clay, for example, has been termed

"The *blue*, the stiff, the never dry!"

by one of our leading geologists, and the same line may very well apply to the Boulder Clay of the north in many instances. Some greenstones, again, on being fractured, are decidedly blue, notwithstanding their name; the weathered surfaces, however, are usually of a dark brown or red, caused by the oxidizing of the iron which they contain.

Violet has a still smaller share than blue in "rock painting," and is represented at best only by a few purplish shales, and some occasional varieties of marbles and phorphyries: oxide of manganese, the colouring principle of the amethyst, is its chief agent.

We have now only those two irreconcilable colours, *black* and *white*, left to deal with.

The first exists in profusion in nature. Thick shales there are throughout the world, of a deep dull black. Most lavas, both old and recent are black. Many clays are more or less black, etc. Instances of black deposits might easily be multiplied, but the blackest of black rocks is undoubtedly coal. Black as coal, is an old saying, and in this case the old saying is a true one. The colour, of course, is merely the normal one of carbon when it is not in the form of diamond. Even the so-called *brown* coal of the newer rocks is generally black, though its streak is brown. Peat, if we may venture to call it a rock, is another instance of black, or more properly perhaps, brownish black.

For a long time the famous Pedras negras were cited as a range of great massive black rocks, but it has lately been shown by a German botanist who went thither, that their colour is due only to a covering of minute dark-coloured vegetable organisms, beneath which the rock is anything but black.

Of black and white, mixed so as to form a kind of grey, there are numerous instances in many of the granite rocks.

White is, as a rock-colour, perhaps more diffused even than

black. In this island it is well represented by the great cliffs of milk-white chalk which gave Albion her name; here again, as in the case of coal, we require no foreign pigment to give the rock its colour, white being the true colour of carbonate of lime in this form. Much chalk though there be on land, there is still more being even now manufactured and accumulated at the bottom of the sea, for it is not long since the world was astonished by being told that the depths of the Atlantic are covered with soft white chalk, ever increasing in thickness, and in every respect exactly similar to our chalk.

But, perhaps, the most beautiful examples of white rock-masses are those formed by the hard crystalline marbles, such as those of Carrara and Paros, which are used in sculpture.

Many limestones, which in their normal and undisturbed state are yellowish, such as the calcareous freestone of which Paris is built, or our own magnesian limestone, become white, or very nearly white by weathering. Clays when nearly pure are white, as kaolin or china clay, and the finer kinds of pipe-clay.

We have now cast a hasty glance over the principal of those colours which affect the general aspect of the land, leaving out of consideration those of which the occurrence is rare, or merely accidental, and we have seen to what chemical compounds the various colouration of the great rock-masses of our earth is mainly due. The subject is one which deserves far more attention than has hitherto been given to it, and to which it is impossible to do justice in a bare outline like the present.

FOREIGN SCIENCE.

Test for Arsenic.—A new and very delicate test for arsenic has been discovered by Bettendorff. Its sensibility is so great, that it is said to be capable of detecting one part of arsenic, in a million parts of solution; and the presence of antimony does not affect it. In order to apply this test, the arsenious, or arsenic liquid is mixed with aqueous hydric-chloride (hydrochloric acid), until fumes are apparent; thereupon stannous chloride is added, which produces a basic precipitate, containing the greater part of the arsenic as metal, mixed with stannic oxide.

Radiation of Heat.—The study of thermic radiation and absorption, has lately occupied the attention of Professor Magnus, who has arrived at some very interesting results. When a substance is heated, and allowed to cool by radiation, it may emit only one kind of heat, or several kinds, simultaneously. Of the former case, pure rock-salt is an illustration: it is monothermic, just as its vapour is monochromatic. On this fact the high diathennancy of rock-salt depends. Nearly all other bodies, when heated to 150° C., emit heat, which contains few or none of those rays which are given out by rock-salt. Sylrine (potassic chloride) resembles rock-salt, but is not equally monothermic. Heat derived from rock-salt is almost wholly absorbed by fluor-spar. If a spectrum could be projected of the heat radiated by rock-salt at 150°, it would contain only one band. Professor Magnus has also instituted some experiments on the reflection of heat of different kinds. Of the heat radiated by numerous substances, unequal amounts were reflected at an angle of 45°; as shown, for example, in the following instances:—

Silver,	between 83	and 90	per cent.
Glass,	„ 6	14	
Rock-salt,	„ 5	12	
Fluor-spar,	„ 6	10	

But of the heat from rock-salt, fluor-spar reflected from 28 to 30 per cent., whereas silver, glass, and rock-salt, returned no more of this heat than in the preceding cases. Fluor-spar reflects 15 to 17 per cent. of the heat from sylrine; less, therefore, than that from rock-salt, and more than that from the other radiating bodies. If our eyes could distinguish different wave-lengths of heat, as they do luminous wave-lengths, and the rock-salt rays were the source of thermic illumination, fluor-spar would appear the brightest of all

bodies, and these latter would commonly display every variety of tint.

METALLIC SPECTRA.—M. Robert Thalén has communicated to the Royal Society of Upsala, a memoir on the characteristic metallic lines of the spectrum, especially with reference to their wave-lengths. As ordinary spectroscopes do not give entirely accordant readings, varying as they do with temperature and other incidental circumstances, it is necessary in all cases to make the solar spectrum the basis of reference. Ångström's "normal solar spectrum" was accordingly the starting-point of the author's researches; and, with this as his guide, he has succeeded in constructing a chart, which gives, in millimetres, the wave-lengths of metallic lines within about 0·0000001 of their true value. Forty-five metals have been thus investigated, and their spectra mapped. Of these, the following give lines coinciding with those in the solar spectrum:—sodium, calcium, magnesium, iron, manganese, chromium, nickel, cobalt, and titanium. The discovery of the last-named coincidence is due to M. Thalén himself.

VINE PESTS.—Many of the continental vineyards have been attacked this year by a grub which infests the root of the plant. M. Marchaud proposes the extermination of this pest by watering the soil with sulphuretted-hydrogen water, which is well known to be very fatal to small animals.

REGELATION.—Pfauudle has put forward a new theory of the regelation of ice. According to Clausius's researches into the constitution of liquids, a perfect equilibrium of temperature in them cannot exist. [Van der Meusbugghe has still more recently shown that liquids are not homogeneous, their exposed surfaces being in a state of tension, and therefore not in the same condition as their principal mass.] Hence, if any *molecular* disturbance take place in one portion of a single fragment of ice which is surrounded by much more, the slight loss by melting, which would locally ensue, would be compensated for by a corresponding increment in some other of its parts. The ice, therefore, must grow in certain directions; and two pieces of ice in contact, or very close to one another, are likely to freeze together.

CHEMICAL AFFINITY.—Thomsen has continued his important and very delicate thermo-chemical researches. Attacking the well-known problem of chemical affinity, by means of thermic phenomena, he selects one case for experiment, viz., the action of hydric-chloride on sodic sulphate in presence of water. His experiments lead him to deny Berthollet's law (that chemical activity depends on

mass × affinity); and, among other interesting conclusions, he demonstrates that hydric-sulphate has more chemical energy than hydric-nitrate.

ADHESION OF AIR TO GLASS.—M. Auguste Houzsau has called the attention of the French Academy to the presence of nitrogen in what was supposed to be pure oxygen. He shows that it is extremely difficult to get rid of the film of air adhering to glass vessels, even after considerable "sweeping" with currents of oxygen, or other gas. In his experiments on the production of ozone by the electric shock, he found it necessary to make the narrow tubes he employed red hot, and while they were in that state to pass oxygen currents through them.

SPONGES AND CORALS.—In the "Annals Nat. Hist." for January 1870, will be found a translation of a paper by Häckel, giving his reasons for asserting that "the sponges are most nearly allied to the corals of all organisms. Certain sponges differ from certain corals, only by a less degree of histological differentiation, and especially by want of urticating organs. The most essential peculiarity of the organization of sponges, is their nutritive canal system, which is both homologous with, and analogous to, the so-called cœlenteric vascular system, or gastro-vascular apparatus of the Cœlenterates."

FRENCH LOCALITY OF PENTACRINUS EUROPÆUS.—M. Lacaze-Duthiers describes, in "Comptes Rendus," living Encrinites on the coast, by Roscoff, between the river of Morlaix, and St. Pol-de-Leon to the east, and the Bay of Poulder to the west, a locality bathed by the Gulf stream. He found them of all ages, on Sargassum. "I kept them," he says, "alive for a considerable time, and the largest, after agitating themselves, and assuming the most graceful forms, metamorphosed themselves under my eyes, abandoning their characteristic peduncles, becoming free, and mingling with adult Antedons, from which they could not be distinguished."

PURIFYING BISULPHIDE OF CARBON.—M. S. Cloez has brought before the French Academy a method of purifying bisulphide of carbon, by keeping it in contact for twenty-four hours with one half per cent. of corrosive sublimate in fine powder, gilding the mixture from time to time. The fœtid matter in the bisulphide combines with the corrosive, and remains at the bottom. The clear liquid is decanted, mixed with 0·02 of its weight of an inodorous fatty body, and distilled in a water bath at a moderate heat. Thus purified, the bisulphide has an ether-like odour.

THE ALLEGED ECCENTRICITY OF THE MOON'S FIGURE.—M.

Delaunay, in presenting to the French Academy a work by Mr. Newcourt of Washington, expressed his belief that the investigations it contained strangely shook, if they did not quite overthrow, M. Hausen's conclusion that the Moon's centre of gravity was considerably removed from its centre of form, or, in other words, that the part turned towards the north was considerably puffed out.

PROGRESS OF INVENTION.

Extracting Juice from Sugar-Cane, Beetroot, etc.—M. Julius Robert Scelowitz has discovered a new method of obtaining the juice from such substances as sugar-cane. The process is one of diffusion. The cane, or substance from which the juice is to be extracted, is cut into slices by a special machine. It is then put into a so-called battery of diffusion vessels, consisting of a series of closed water-tight tanks, and is brought into contact with water at an elevated temperature, in a certain succession and systematic order, which is requisite for complete extraction, and for the proper concentration of the juice obtained. Another application is also described, the main feature of which consists in carrying out the whole process of diffusion in one single vessel, or diffuser, in which the extraction of the sugar is carried on continuously by introducing slices of cane through a feeding apparatus at the bottom of the vessel, from which they rise slowly to the top, while fresh water is constantly running in at the top of the diffusion vessel, and is drawn off at the bottom as diffusion juice, after having remained in contact with the slices for a sufficient length of time. The liquid during this operation is agitated by machinery. Could not this principle be applied on a small scale for domestic uses, as in the making of such drinks as lemonade?

Securing Corks.—The ordinary method of fastening corks into soda-water bottles is well known. Mr. W. M. Littell, of New Jersey, proposes a new method, which consists in the use of a clip, or fastener, the ends of which are jointed or secured in eyes or loops formed in a ring encircling the neck of the bottle. The clip or fastener is formed with two arms extending up at the sides of the cork, which arms are united by a cross-piece intended to rest upon the top of the cork when it is placed in the bottle. The clip is made of iron wire, coated with tin, so as to prevent oxidation, and the top, or cross-piece, is bent so that the central part projects over,

and secures the cork, when it is released from the corking machine; while the sides of the cross-piece are curved in the opposite direction, which facilitates the adjustment of the clip over the cork. The advantage of this invention is that it can be used by persons who have no special skill or experience in bottling liquids under pressure.

WINDOW SHUTTERS.—Mr. Jackson, of Bradford, constructs window-shutters in the following manner:—Laths, or narrow strips of wood, are arranged horizontally and hinged together, the joints being on alternate sides, so as to allow them to fold in a zigzag manner one upon the other. A box is also formed to receive them, and is placed under the window bottom, between the masonry and the lining. A cord or chain is fixed to each end of the top lath, and is passed over pulleys fixed in the top of the window-frame, and both cords are attached to balance-weights. Grooves are formed in each side of the window casing for the shutters to work in. When the shutters are lowered into the box they are concealed by a lid.

TOOLS FOR CUTTING GLASS.—The diamond is the material almost exclusively used in cutting glass. It, however, requires considerable skill and practice to use it efficiently. Moreover, it is a costly material, and very liable to be injured by accidental causes. A method of cutting glass, which does away with the use of the diamond, has lately been patented. It consists in cutting or producing a continuous fracture along the surface of glass by compression. A tool is employed in the form of a disk, which is made to revolve on its axis as it passed over the surface to be cut. In practice it is formed by the end of a cylindrical shaft, made of steel and hardened; it should be about one-twentieth of an inch in diameter, and when so made it has a cutting edge of an angle of 90°. The shaft is mounted on a frame, and made to revolve on friction-wheels, to lessen resistance as much as possible, and is held so that the axis of the shaft is perpendicular to the line of progress, or nearly so; and at an angle of 45° to the surface of the glass, and when the tool is in this position, it is drawn forward by the hand with a moderate downward pressure, the angular edge of the disk in the mean time receives a lateral rotative motion compared with the line of progress on the surface of the glass, and so produces a continuous fracture similar to that made by the downward. The tool, however, can be provided with a means for guiding it over the surface of the glass, so that a cut of any form can be made.

MORTAR.—The disadvantages arising from those kinds of mortar at present in use are chiefly owing to inferior sand being used, and

the great difficulty of obtaining sand at a moderate price. A material has been invented which does away with these difficulties, for when used it requires only to be mixed with water. In order to make one ton of this mortar, the following substances should be ground by machinery: 288 lbs. of lime (either caustic or the hydrate), 1728 lbs. of slag, and 224 lbs. of calcined coal-shale clay. These materials having been ground to the degree of fineness required, are mixed, and are ready for use. From the nature of the substances used, there would be, doubtless, a more rapid chemical action than that which takes place in ordinary mortar. For plastering purposes the compost seems to be eminently suitable.

Manufacture of Magnesium.—Messrs. Larkin and White, of Hampstead, thus describe their "Improvements in the manufacture of magnesium, and in the preparation of its anhydrous chloride:" "Magnesium is obtained by the reaction of sodium on the anhydrous chloride of magnesium, and the chloride of magnesium is prepared by dissolving the carbonate in hydrochloric acid. We use or add acid in such proportions, that in the solution obtained it shall be considerably in excess. We then partially dry the acid solution in thin layers in covered dishes, taking care that there shall be sufficient aperture for the ready escape of the acid vapour. The vessels used are of glazed porcelain. When the acid solution is thus made as dry as can be conveniently done, we remove the residue from the evaporating dishes, and fuse it rapidly at a red heat, the crucibles being closed. The partial drying of the chloride, and its subsequent fusion, may be very rapidly accomplished by passing streams of hydrochloric acid gas over the material, first at a moderate heat, and then fusing as quickly as possible at a red heat. These operations may readily be carried on upon an enormous scale at the various soda works, by utilizing the almost waste fumes of hydrochloric acid gas as they pass from the salt cake furnaces in the production of sulphate of sodium from common salt. We also obtain chloride of magnesium by dissolving the oxide in chloride of ammonium, and by heating them together in a covered vessel. In this case the ammonia is given off, and can be collected, while chloride of magnesium remains. Having obtained the chloride of magnesium, we proceed to obtain the metal from it by placing it with a proper equivalent of sodium in a plumbago crucible or retort, the retort being constructed with a neck having a stopper accurately fitted into it. The mixture is then exposed to a full red heat, and the reaction is completed. The stopper is then quickly removed, and a condenser fitted on to the neck of the retort. When all is

thus arranged, the heat is increased until the metallic magnesium is distilled off, and received into the condenser."

Crucibles.—The object of this invention is one of considerable importance; it is to produce better and cheaper crucibles, or other refractory articles to be used in metallurgic operations, or in laboratories. Pure alumina is used instead of plumbago, and this alumina is mixed with as little clay as possible in the manufacture of crucibles. Porcelain crucibles, and evaporating dishes, and other articles of that nature, may be also made by mixing alumina with a little porcelain clay. They are found to be very strong, very refractory, and very little subject to chemical action. The inventors are John L. Hall and James Morgan, Montreal, Canada.

Waterproof Garments.—At present in the use of waterproof garments great inconvenience is experienced from the want of escape of the natural moisture exuded from the body. Messrs. Thomas and Jesse Fagg, of the Haymarket, have patented a method of obviating this. They apply to waterproof garments a series of elastic tubes of vulcanized india-rubber, or other material of sufficient thickness and strength to resist any ordinary compression, but still of sufficient elasticity to yield freely to the movements of the wearer. These tubes are attached to the interior of garments by strips or bands coated with adhesive solution; by this means they assert that a free circulation of air under the garment is obtained.

Reducing Ores.—If successful, a very important invention has been patented by Mr. Benson, of Hexham. He proposes to use edge-runners for crushing minerals instead of stamps. The experiment has been often tried, but with very imperfect results. The new method proposed is as follows:—The ores or minerals are fed to the runners by means of an upright hollow shaft, the lower portion of which is conical, and over the exterior of the cone, and through openings in the shaft, the ores and minerals are carried by thin streams of water to the bottom of the pan, and underneath the edge rolls. By this means they are reduced to a fine thin pulp; or they may be fed under the runners by spouts or conduits from the exterior, or through the rim of the pan.

Umbrellas.—Silk umbrellas are liable to wear in the folds between the ribs. In order to prevent this, Messrs. Johnson and Hatchman, of Wood Street, City, propose to employ, as a thickening material, where the folds occur, a substance which will not form into *sharp* folds, or well-defined creases; they make an umbrella,

therefore, of silk, but with certain parts lined with linen, or some other such material.

Perambulators.—In order to prevent the exposure of children to cold by facing the wind or rain, Mr. William Martin, of Manchester, makes perambulators which are capable of being reversed on their frames when required. The body is socketed on to the frame, so that it can be moved easily, the movement being checked by pins or catches. He also arranges the body and frame so that the foot of the body can be raised so as to enable the occupant to be in a recumbent position. This is effected by the use of a lever, or a rack and pinion.

Obtaining Gelatine.—Crude animal substances, such as the flesh, fat, skin, tendons, bones, etc., either with or without a previous treatment with lime, are treated with benzine, or some other similar hydro-carbon, in a vessel provided with a condensing apparatus for saving any vaporised benzine, or in a closed vessel at an elevated temperature. After a few hours' digestion, the hydrocarbon solution of the fats and oils is drawn off, and may be treated by any of the well-known methods for recovering the volatile hydrocarbon, which may be again used in subsequent operations. The oils and fats are saved and utilized. The animal matters, or purified glue stock, is now ready for conversion into gelatine by heating with water in the ordinary way.

Cord Tightener for Curtain Fixtures.—The following is a very neat method for tightening the endless cord used in window-blinds. The pulley over which the cord passes is mounted on one arm of an L shaped slide, the other arm passing inside a helical spring, and these are mounted in a slotted tubular case that is to be fastened to the window-casing, or other place, so that the helical spring acts upon the pulley to keep the endless cord at the necessary tension to act upon the curtain-roller, and the spring yields to any contraction or expansion of the cord under atmospheric changes. The arm of the pulley-slide, being within the spring, cannot become obstructed in its movement in the tubular case.

LITERARY NOTICES.

Homer: the Iliad. By the Rev. W. Lucas Collins, M.A., author of "Etoniana," "The Public Schools," etc. (Blackwood and Sons.)—This pretty book is the first of a series; and there can be no doubt that if those which follow exhibit anything like as much literary skill and scholarship, as Mr. Collins has brought to his task, a great success will be achieved.

Mr. Collins tells the story of the Iliad, in capital prose, interspersed with judicious observations, critical, historical, and explanatory, and when he comes to the more important passages, he gives them in the versions of Lord Derby, Pope, or other translator. We wonder he has omitted old Chapman, and others we could name, and we think he has resorted rather too much to Pope. "Pope's" Homer, however great its merits, is the least like Homer's Homer of any translation in existence. It is paraphrastic where the old Greek is direct; highly artificial where the original is simple; and the monotonous versification differs as much as possible from the Homeric metre, which has the variety and flexibility of blank verse. But, although we should have been more pleased with less Pope, we must acknowledge that Mr. Collins has selected many of the favourite passages from that author, and altogether he has produced a very charming book, which will do more to make English people understand Homer, than any publication which has yet appeared. Let any one try the experiment of reading a chapter aloud in the family circle, and if he reads tolerably well, his audience will not let him off, till the final page is reached.

Geology and Revelation: or the Ancient History of the Earth, considered in the Light of Geological Facts and Revealed Religion; with Illustrations, by the Rev. Gerald Molloy, D.D., Professor of Theology in the Royal College of St. Patrick, Maynooth. (Longmans.) —We learn from the preface, that Dr. Molloy saw, as a theologian, the necessity of his understanding the leading facts and arguments of geology, in order that he might be able to judge of the relations between that science and revelation. An ordinary theologian would have followed the common practice of writing about geology in profound ignorance of the subject; and so much rubbish of this kind has been published, that scientific men will now rarely look at

books professing the object Dr. Molloy had in view. By going honestly to work, he has produced a valuable volume, and the sturdiest Protestant need not be afraid of it because it issues from the College of St. Patrick, Maynooth. The greater part of the volume is occupied with an able epitome of geological science, in which facts, arguments, and inferences are fairly stated. This makes the book a good scientific manual. Then comes an inquiry into the Mosaic account of creation, and the interpretations which the most learned students in all ages have placed upon it. This part contains a great deal of curious and scholarlike matter, quite out of the ordinary range of theological reading. We do not enlarge upon it, because theology is beyond our scope, but we may state that Dr. Molloy arives at the conclusion, that the geological doctrine of the antiquity of the globe, is in harmony with the best expositions of the Hebrew writings. In another volume he promises to take up the question of the antiquity of man, and if, as we may expect, he treats it with equal learning, his labours will command attention and respect, whatever may be the conclusions to which he arrives.

Faraday as a Discoverer. By John Tyndall, New Edition. (Longmans.)—We are glad to see that a new edition of this work has been called for. The present is, we believe, in a cheaper form, and will be a welcome addition to the student's library. Like the former edition, it contains two portraits of the great philosopher.

Microscopic Objects Figured and Described. By John P. Martin, Secretary to the Maidstone and Mid-Kent Natural History Society. No 1. (Van Voorst.)—The object Mr. Martin proposes to himself in this publication, is to supply "an accurate drawing and description" of objects likely to be found in cabinets of microscopic objects, or which may be readily procured." It will be issued in parts, each one containing eight plates and eight pages of letter-press, the whole to comprise about 200 figures, and to form an octavo volume. The descriptions will be adapted to "those who wish to become acquainted with the curious and beautiful appearances presented by the microscopic components of natural bodies, without entering deeply into their functions and uses." Judging from the plates and letter-press in the part before us, the work will be a pleasant and useful aid to the class for whom it is designed. The plates in this part relate to vegetable objects, yeast, maple blight, sections of pith, and wood, etc.

THE FLORAL WORLD, No. I., 1870. (Groombridge and Sons.)—"Fuchsias, Old and New," with a coloured plate of "Banks's Perfection," supply matter for the first paper in this number. Mr. Fairbairn gives directions for growing Orchids in Greenhouses at a moderate heat, with a list of those best adapted to the purpose. We notice also a valuable article on "Flowering Shrubs for English Gardens," signed by the well-known initials S. H., and other useful matter.

MISCELLANEOUS NOTES.

EARTHQUAKE AT BISKRA, ALGIERS.—At Biskra, South Algeria (35° lat.), from the 16th to the 19th of November last, strong earthquake shocks were felt, houses cracked, bells rang, trees swayed to and fro, and a dull rolling noise was heard. In some spots dark "plumes" rose in the air, as from volcanoes, they were dust clouds from falling buildings. The shocks seemed to follow a quarter of a circle from east to south-east, with a radius of thirty to forty kilometres, the north-eastern chord of the arc being formed by the chain of Aurès.

PLATINIZED GLASS.—M. Wailly, of Aisne, platinizes glass as follows: The glass is thoroughly cleansed and placed vertically, to receive the platinizing liquid. This is first spread from the bottom to the top, then from left to right, then from the top to the bottom, and finally from right to left. Thus the oily layer is spread equally and dries slowly without running. To make the liquid he takes 100 grammes of finely laminated platina, desolves it in aqua regia; evaporates to dryness in a sand bath, avoiding the decomposition of the protinic chloride. It is then ground up on a stone with a muller, with successive additions of oil of rectified lavender. The reaction takes place on the glass, and it is necessary to avoid, in the preliminary preparations, too much oil, or too high a temperature. When about 1,400 grammes of oil of lavender has been added to the above-named quantity of platinum, the mixture is placed in a porcelain capsule, and left to repose for a week. It is then decanted and filtered; decanted again after six days, and filtered again. The filtered liquid *doit moiquer* 5 *degrés au pési acide*. As a flux for the quantity of platinum named, twenty-five grammes of litharge, and the same of borate of lead, are rubbed up with eight to ten grammes of oil of lavender. This is well stirred, and mixed with the platinizing fluid. When the glass is covered with a layer of metal, and is dry enough, it is placed in a muffle of special construction, and the decomposition of the platiniferous resin, and its transformation to charcoal is effected without fusion, ebullition, or bubblings, and the spongy skeleton formed by the cinders, is fixed and

transformed into a perfect platinization. This is perhaps intelligible though not very clear. The platinized mirrors are found to be very brilliant and cheap. One franc's worth of the metal will cover a square metre of the glass, the *front* surface of which is coated.

CHINESE OBSERVATIONS OF COMETS.—Mr. Williams, the Assistant Secretary of the Royal Astronomical Society, has recently presented to that body a MS. translation of Chinese observations of Comets, from B.C. 613, to A.D. 1640. This is a work of great labour and merit, and we hope it will not be buried in the Society's library, but suitably published.

NOVEMBER METEORS, 1869.—The "Monthly Notices" contain Mr. Tupman's observations of these meteors at Port Said. He found that no single radiant-point would satisfy all the paths observed, so that their orbits cannot be identical in inclination and eccentricity.

AURORAS AND MAGNETISM.—In "Monthly Notices" for December 10, 1869, will be found a brief paper, by Mr. Balfour Stewart, suggesting that auroral displays may be secondary currents, due to small but rapid changes caused by some unknown influence in the magnetism of the earth.

THE MELBOURNE TELESCOPE.—The following is from an Australian paper. "The work of drawing and observing the nebulæ of the southern heavens with the great telescope, is progressing steadily at the Melbourne Observatory. A good deal of delay is caused by the many adjustments and alterations which are constantly required to be made to the telescope, a portion of which are due to faults of construction, and others are suggested by experience in working the instrument. The nature of the work on which the telescope is at present engaged, prevents any very rapid results being realized, it being probable that some of the work at present in hand, will not be finished until the end of the year. Another drawback Mr. Ellery has had to contend against, is, that on unvarnishing the second speculum, it was found that the coating had injured the polish of the reflector, which will have to be repolished before it can be used: this will cause some delay. The astronomical photographic apparatus has not arrived from England, although it has long since been paid for. The other branches of the work at the Observatory, are progressing in a most satisfactory manner, and the Victorian portion of the survey of the southern heavens is being pushed forward as rapidly as circumstances will admit."

PREMIUMS FOR ODOURS OF PLANTS.—The following Premiums have been placed at the disposal of the "Council of the Society of Arts," for the term of seven years, by Dr. Septimus Piesse, Esq., F.C.S.:—

1. A Premium of £5, for one pound of otto of bergamot, of the value of 16s., or more, in the London market, being the produce of plants (*Citrus bergamia*) grown in Australia, New Zealand, Natal, any

of the British West India Islands, or any other British Colony or Dependency.

2. A Premium of £5, for one ounce of otto of roses, of the value of 20s., or more, in the London market, being the produce of any variety of roses grown together in one plantation in Australia, New Zealand, Natal, any of the British West India Islands, or any other British Colony or Dependency.

3. A Premium of £10, for a canister of enflowered butter, or fat, so scented with any kind or sort of flower, either by infusion or enfleurage, or by means of these processes jointly, of the weight of 3 lbs. or more, and of the value of 6s. per lb. in London. The said butter or fat to be enflowered or infused with flowers grown for the purpose in Australia, New Zealand, Natal, any of the British West India Islands, or any other British Colony or Dependency.

ARTIFICIAL GEMS.—M. A. Gauden lately read a paper before the French Academy on this subject. He endeavours to obtain his artificial products free from crystallization, and quite limpid. The crystals he sometimes forms, though interesting to science, have not the character he requires as substitutes for precious stones. He operates in porcelain vessels, varying the formulæ indefinitely, with different proportions of sand, aluminium, kaolin, talc, lime, etc., keeping as near as possible to the formulæ of granite, as that substance is naturally viscous after fusion, and it is difficult to devitrify. He says, that he especially endeavours, with the help of the oxyhydrogen blow-pipe, to produce really fine stones, not yielding to the file, and at least as hard as each crystal. In crucibles, he states, that the hardness is only obtained at the expense of devitrification, and the stones are only half good.

THE COURTSHIP OF BIRDS.

BY T. W. WOOD, F.Z.S.

(*With two Plates; one coloured.*)

THE study of Ornithology is by no means neglected in the present day, good and useful works on this delightful subject are rather frequently issued; yet one branch of it has been most inadequately dealt with by authors, artists, and taxidermists. I allude to the courtship of birds, a phase of their existence which most assuredly cannot yield to any other in interest and entertainment to those who study and admire nature's marvellous works. It is the tender passion (albeit a very strong one) which prompts the nightingale and skylark in their songs, the cuckoo and many other birds to utter their call notes, and the peacock to spread out his glories in the sunshine, in hopes to win the favour of his mistress, that she may look "and find delight writ there with beauty's pen."

The popular idea of the peacock's disposition is well expressed by the proverb "as proud as a peacock." My own opinion, however, after closely watching the bird's actions, does not quite coincide with this; still I may be mistaken. All we know for a certainty is that creatures so highly decorated as the peacock, birds of paradise, and others belonging to different orders of animated existence, are always possessed of the power and disposition to display those decorations. This action of display is performed by the males, generally, though not always in presence of the females, and undoubtedly has for its object the winning of their favours. How intently is the attention of the peacock fixed upon the peahen when he stands before her with his glorious train of oscellated feathers fully expanded! Still this bird will often spread out his plumes when not blessed with a female companion, and the peahen sometimes erects her tail and tail coverts; but we cannot attribute this action of the hen to a feeling of pride, seeing how little beauty of colour she is possessed of. When the peacock expands his train, the wings and under parts of the body are entirely hidden from the view of an observer standing in front of him. The specimen in the national collection is incorrect in this and other respects, and the only stuffed specimen which has struck me as being true to nature, was in the Great Exhibition of 1851. The very peculiar feathers which border the peacock's train are most probably the

upper tail coverts, the rest of the feathers composing it grow from the lower part of the back.

Birds are gifted with an instinct which impels them to act as if they knew what part or parts of their bodies are specially decorated, these decorations being always displayed fully, and in the best manner possible during courtship. The peacock as we have seen conceals his wings while displaying his more showy plumage; but the peacock-pheasant, or Polyplectron, displays the wings; as they, with the tail, are most chastely ornamented with gem-like spots. The note of this bird is a sort of coarse laugh, not uttered during display, but generally while perched, and so frequently repeated when it once begins as to tire the ear of anybody obliged to hear it.

The wild turkey of Honduras, *Meleagris ocellata,* is perhaps more varied and brilliant in colouring even than the peacock, though not possessed of a long train. This magnificent bird is not a true turkey, but assimilates to the Polyplectrons in many details of structure; and like those birds, it can, while strutting, move its expanded tail, so as to give the observer standing at the side of the bird a full view of it. A fine male of this species was strutting about at the Zoological Gardens with great apparent pomposity one fine morning, not looking to see where he was going, when he suddenly stepped into the water in the centre of his compartment; his ardour was thereby greatly cooled, and he presented a very comical appearance for a short time. The bare skin of the head and neck of this rare bird is light greyish blue; space round the eye and tubercles on the neck, coral red; tubercles over the eyes and on top of the head, light orange buff; legs and feet, coral red.

The monal or impeyan pheasant, *Lophophorus impeyanus,* of the Himalayas, is very fond of "showing off," as it may be called. I have seen him taking very long strides, stopping a moment between each, with the beak bent down and touching the neck, the light greenish blue skin round the eye extended backwards, and the crest erected, the ear coverts also appear to project, the beautiful wings by being slightly opened and elevated are fully shown, excepting the black primaries, which are concealed, the tail is spread, and if the female be at the side of the bird, the male bird hides his black breast and under parts on that side nearest to her by extending the brilliant plumage of the neck downwards and lowering one wing. There is a pair of these birds in a separate case at the British Museum, in which the male is represented as paying his addresses to his mate; but the peculiarities just mentioned have not

been attended to, still the arrangement is artistic and the beautiful plumage is well seen.

I will call the action last alluded to the lateral, or one-sided mode of display, and the more typical pheasants seem to possess no other method. We may reasonably conclude from this that the females of these birds prefer colour and markings to beauty of form, as the males distort themselves in order to show a greater number of beautiful feathers than could be seen otherwise at one view. A description of this very peculiar attitude need not be attempted, as the figure of the Japanese pheasant (*Phasianus versicolor*) on Plate II., sketched from life at the Zoological Gardens, will convey the idea at once to the reader. It will be seen how greatly the skin round the eye (of a bright vermilion colour) is extended, and the little purple aigrettes are erected. The common partridge (*Perdix cinerea*), displays one side to his mate; so do the horned tragopans: but these birds have other modes in addition, for a description of which the reader is referred to No. xx. of the "Intellectual Observer." I regret to state that all the specimens of the species described in that article, including the young ones, have since died; but Temmnick's tragopan (*Ceriornis Temminckii*) has taken their place in our aviaries. This species is somewhat smaller, but stouter in build than the other, and possesses a much larger wattle, which is square at the lower end. This magnificent appendage is of a deep ultramarine blue in the central part, which colour descends in a broad band from the throat to the extremity of the wattle, and is regularly spotted with light blue; the lateral bands, much more numerous than in the other species, are also of this latter colour, and the space between each is filled in with a most lovely carmine; it is edged all round with light blue. I was fortunate enough to obtain a good sight of the wattle one fine evening in spring, while the bird stood very still on an elevated perch in a grotesque, almost comical, attitude; nearly all his feathers being erected, his crest expanded laterally, and his wattle pendant, but not expanded; he looked as if bent upon sport or mischief. The wattle and horns are fully exhibited only when the male is paying his addresses very ardently to the female. I have only seen this species do so once; this was at the Zoological Gardens, and my vexation was great at not being able to place myself so as to obtain a front view of the bird, owing to the door of the aviary being kept locked; and I will here express my opinion, that a fellow of the society, who sits and watches the birds for hours, and who would take every care not to disturb them, ought to be allowed

every facility for prosecuting his researches. On the occasion referred to, it was evident that the wattle was being let down, and also expanded on each side like a large and gorgeous apron, covering half, and perhaps more, of the bird's body in front; the horns were then seen to be of a very vivid light greenish blue, and the edge of the wattle viewed from behind, carmine. The cheeks in this bird are bare, and of a blue colour.

The last, though not least remarkable example of the lateral mode of display which will be mentioned here is the golden pheasant (*Thaumalea picta*), whose elegant form and brilliant colouring are so well-known in this country. The male runs very playfully after the female, and placing himself in front of her, quickly expands his collar, bringing nearly the whole of it round to the side where it is to be exhibited, and thereby presenting to view a flat disc of bright orange red, banded with perfect regularity byblue-black semicircles; the hen on seeing this frequentlyruns away pursued by her would-be mate, who generally finds himself placed with his other side towards her, and the collar is accordingly shown on that side. At the moment the full expansion of the collar takes place the bird utters a very snake-like hiss, which, according to our notions, would not be very fascinating as a love-song; the body is very much distorted, as is the case with the true pheasants, but the tail is not spread so much, as the curved, roof-like shape prevents its forming a flat surfrce. Slight breaks would occur in the black stripes of the collar when expanded were it not that each feather has a second black stripe which is so placed as effectually to prevent this.

Nature has, in one of her fits of eccentricity, furnished the males of certain species of grouse in America with large pouches, or windbags. The pinnated grouse (*Tetrao cupido*), well known in its native land as the Heath hen, is a good example of them. In the year 1862 a considerable number of these birds, mostly of the male sex, were living in the Zoological Gardens, and I had an excellent opportunity of observing their actions, as I was in a compartment of the aviary in which was a male and female: the coloured plate will convey an idea of their appearance; the male bird in the background is represented having his neck plumes pendant. This curious fellow commences his eccentric performances by erecting his long wing-like neck plumes till they meet over the top of his head; he also erects and expands his tail, showing the white under coverts, and with drooping wings, trots, or toddles along (the movement is not like walking), slightly turn-

COURTSHIP OF BIRDS.

[*See page* 125.

ing in his course, and accompanying his steps with a knocking noise, which somewhat resembles the sound made by water escaping from an inverted bottle, and is not loud—indeed, I question whether I should have noticed these curious sounds had I not sat perfectly still; but, as it was, the bird showed no signs of fear, but frequently came so close to me that I could have touched him. And I would here observe that this stone-like stillness must frequently be adopted by those who desire to study the habits of wild creatures. But to return to my description. After strutting a short distance in the manner described, the bird stands still and utters his own peculiar "cock-a-doodle-doo," in doing which he does not raise his head nor open his bill, but he suddenly inflates his neck-pouches, and gives vent to his feelings in three rather loud windy hootings, of which the first note is the highest and the second one the lowest. If he hears a rival he utters a loud *quawk*, indicative of the highest excitement, and repeats his own performances with renewed energy. The beautiful yellow combs, with serrated edges, one over each eye, must not be forgotten. They are seen to sprout, as it were, from amongst the feathers at the same time that the neck plumes are raised. These plumes hang down and cover the naked pouches when the bird is not strutting. The pouches, when inflated, are about the size of a large orange, which fruit they also resemble in colour, with the exception of being slightly darker and tinged with brown, and there is an elongation towards the head of a carmine colour. The figure of the pinnated grouse strutting, as given by Wilson, in his "American Ornithology," is extremely inaccurate; and it is a pity that, when he went out to observe these birds in their native haunts, he should have used his gun before doing justice to them by his pencil and note-book. The bird does not flutter his neck-wings, as stated by this author, but merely erects them. Audubon has not attempted to represent the strutting attitude of these birds, but has figured two males about to fight. I will say, at the same time, that both his and Wilson's accounts of their habits are very entertaining. The cock of the plains (*Tetrao urophasianus*) is a very fine example of a pouched grouse. The ruffed grouse (*T. umbellus*) is a smaller species, but very handsome, and I do not despair of seeing them alive at the Zoological Gardens.

The following facts relating to the pinnated grouse are extracted from a letter communicated by Dr. S. L. Mitchell, of New York, to Wilson's "American Ornithology." Dr. Mitchell's observations were made in that peculiar tract known as the Brushy Plains of Long Island, probably for time immemorial a resort of this bird.

He found them inhabiting chiefly the forest range, a district between forty and fifty miles in length, extending from Bethphage, in Queen's County, to near the Court House, in Suffolk. The breadth of this district is not more than six or seven miles. The situation is so retired, that the game laws are habitually disregarded, informers being easily silenced by bribes. The birds are assailed on all sides almost without cessation, and their scarcity may be viewed as foreboding their eventual extermination.

"The season for pairing is in March, and the breeding-time is continued through April and May. Then the male grouse distinguishes himself by a peculiar sound. When he utters it, the parts about the throat are sensibly inflated and swelled. It may be heard on a still morning for three or four miles; some say they have perceived it as far as five or six. This noise is a sort of ventriloquism. It does not strike the ear of a bystander with much force, but impresses him with the idea, though produced within a few yards of him, of a voice a mile or two distant. This note is highly characteristic. Though very peculiar, it is termed *tooting*, from its resemblance to the blowing of a conch or horn from a remote quarter. * * * The males' places of assembly are called *scratching places*. Men lying concealed near these places of resort have been known to discharge several guns before either the report of the explosions or the sight of their wounded and dead fellows would rouse them to flight."

Wilson says that these birds inhabit different and very distant districts of North America, and that they are very particular in selecting their places of residence. Open, dry plains, thinly interspersed with trees, or partially overgrown with shrub-oak, are their favourite haunts. They have a dislike of ponds, marshes, or watery places, which they avoid, and never drink from them: a hen in confinement was observed even to avoid that part of her cage in which the water was placed, but she picked it eagerly, drop by drop, from the bars, when it was allowed to trickle down them.

"The three notes are of the same tone, resembling those produced by the night-hawks in their rapid descent; each strongly accented, the last being twice as long as the others. When several are thus engaged, the ear is unable to distinguish the regularity of these triple notes, there being, at such times, one continued humming, which is disagreeable and perplexing, from the impossibility of ascertaining from what distance, or even quarter, it proceeds. While uttering this, the bird exhibits all the ostentatious gesticulations of a turkey-cock—erecting and fluttering his neck wings,

wheeling and passing before the female, and close before his fellows, as in defiance. Now and then are heard some rapid cackling notes, not unlike that of a person tickled to excessive laughter; and, in short, one can scarcely listen to them without feeling disposed to laugh from sympathy. These are uttered by the males while engaged in fight, on which occasion they leap up against each other, exactly in the manner of turkeys, seemingly with more malice than effect. This humming continues from a little before daybreak to eight or nine o'clock in the morning, when the parties separate to seek for food."

Birds of the grouse tribe, however, do not stand alone in the possession of these curious air-bags, as they are a well-known feature of some species of bustard. The common bustard (*Otis tarda*), formerly found wild in this country, is an example, and its very singular aspect during display has been portrayed by Mr. Joseph Wolf, in his "Zoological Sketches." The large Australian bustard (*O. Australasianus*) is equally remarkable. The Zoological Society are fortunate enough to possess examples of this bird; and, for the last three or four years an adult male may have been seen putting on an appearance which, I should think, few other birds would envy. This great change in the outlines of the male takes place in the spring, and continues to the early summer time; and what a change! From his breast hangs loosely a large pouch covered with whitish feathers, and so long, that it reaches the ground; the tail appears to lie on the back, and is just long enough to touch the neck: the feathers of the tail are not spread, and this is somewhat remarkable. The skin of the throat seems to be distended with air, the white feathers in that part all standing on end, the head and neck appear very stiff, the bill pointing upwards, and giving the bird a haughty aspect; the very large pouch swings to and fro with every action of the bird, and his movements are greatly impeded by it. The call note is, I am afraid, indescribable; yet I will endeavour to convey some idea of it to the reader. The head is lowered for a moment, the bill is then opened and closed with great violence, and this causes a loud *pop* to be heard; the head is then raised, and a curious vibrating sound is produced, during which the whole body is seen to quiver.

The figure of the black grouse (*Tetrao tetrix*) crowing, is copied from a drawing by Mr. Wolf, who has kindly favoured me with the following account of his own observations while at Odenwald in Germany—"These birds select open spaces in their native woods, where they arrive at dawn of day. The males commence by a sort of

hoarse crow; they also utter a much louder crowing note which could be heard for a mile or so when all else is quiet. In the midst of their strutting, a male will suddenly start in the air with a great fluttering to a height of eight or ten feet, and descend almost to the same spot. Of course there is sure to be a fight if two rival males approach each other. The peculiar call-note of the hens is *cuck, cuck, cuck,* which may be heard in the surrounding woods, and they will also, sometimes, come to the open. The strutting, probably, does not last after sunrise as the birds then retire into the woods. The combs over the eyes are of a very bright-red colour, full and round, like strawberries (not flat, as in the dead bird), forming a very conspicuous feature when the sun is shining, with green grass, or heather, for a background." Mr. Wolf also saw the capercailzie (*Tetrao urogallus*) to advantage when performing on a tree on which he had been roosting. This bird also begins at dawn of day with a kind of double click, which resembles the sound produced by striking two hard pieces of wood together; these sounds are gradually increased in number, and become quicker in succession, till at last they culminate in a hissing. Whilst he utters this last sound his neck is stretched out straight to its full length, the wings are drooped, and the tail is erected and spread; the head is seen to vibrate violently, and the bird at that moment seems neither to see nor to hear; for even if fired at, at that moment, and missed, it is well known he does not seem to be aware of the fact. The vibration is so strong that, according to Mr. Lloyd, it is communicated even down to the trunk of a large tree on which the bird stands. This fine grouse possesses a sort of beard formed by the elongation of the throat-feathers, and these are thrown forwards during display. On hearing the call-note the hens will congregate on the ground, they also possessing a call-note rather louder than that of the grey hen; sometimes one will alight on the same tree with the male, these being more arboreal in their habits than the black grouse.

A portrait of the bell-bird (*Chasmorhynchus nudicollis*), in a very singular attitude, is given in Plate II. This bird will occasionally stop in the midst of his song (if such it may be called), and assume the curiously strained position represented, remaining for two or three minutes as still as a statue; suddenly he will bend his head down, moving it rapidly, as if nodding to his neighbours in the next cage. This attitude of the head is also shown in the Plate. The bill at this time is open, and a very low gobbling note is uttered. For further particulars of the bell-birds the reader is referred to an article in No. lx. of the "Intellectual Observer." The birds of

paradise, which should be mentioned here, will not be further alluded to than by stating that the actions of the two individuals which were at the Zoological Gardens, have been described in No. viii. of the "Intellectual Observer."

In the proceedings of the Zoological Society of London, Mr. A. D. Bartlett gives the following account of the very singular antics of the kagu (*Rhinochetus jubatus*), as observed by him: "With its crest erect, and wings spread out, the kagu runs or skips about, sometimes pursuing and driving before him all the birds that are confined with him in the same aviary—among these are several blue water-hens (*Porphyrio*)—evidently enjoying the fun of seeing them frightened; at other times he will seize the end of his wing or tail, and run round, holding it in his bill; from a piece of paper, or dry leaf, he derives amusement by tossing it about and running after it. During his frolic he will thrust his bill into the ground, and spread out his wings, kick his legs in the air, and then tumble about as if in a fit." The sun bittern (*Eurypyga helias*) is another bird whose wings are expanded during play, and courtship also, no doubt, and most charming are the contrasts of colours on the flight feathers; indeed, during flight, the creature looks like a very large and gaily painted moth.

But by far the most notable example of wing ornamentation is seen in the argus pheasant (*Argus giganteus*), whose lovely blended tints and intricate markings seem to set faithful description and imitation at defiance. I wish to call attention to one or two curious facts relating to this bird. The large oval spots so conspicuous on the secondary quill feathers which have hitherto always been considered to resemble eyes, and from which the bird derived its name, if attentively studied, will be seen not to resemble eyes at all, but appear, at a little distance, like rows of convex and highly-polished pebbles, set in the web of each feather. The stone which they resemble most nearly, as far as I can ascertain, is the *cat's-eye*, which comes to us from India, and the general effect of the whole design would strongly remind an architect of an embellishment known as the *egg and dart* in classic architecture. The oval spots present exactly the appearance of having been painted with consummate skill by an artist whose perfect knowledge of the laws of light and shade enabled him so to deceive the eyes as to cause a flat surface to appear convex. An artist will generally arrange the lights and shades of his work on the very correct supposition that the chief light proceeds from above, especially in out of doors subjects; and, marvellous to relate, this rule has been rigidly adhered

to by Nature in the painting of the spots on these feathers, and in them we find an index pointing, as it were, to the position in which the wings are placed, when displayed by the bird. And what is that position? To a certainty the wings are widely expanded, and it is almost as certain that they are erected and placed much in the same position with regard to the bird's body as the peacock's train; for in this way only would the light appear to fall truly on the apparently raised spots. Then, indeed, would the appearance of convexity be perfect, for the lights and shades of these large spots are slightly varied on each succeeding feather; and this is necessary, so to speak, as some few of the secondary quills are placed in a line with the direction of the light, while others are almost at right angles to it. Strange and mysterious does it seem that such a superabundance of the most beautiful ornamentation that can be imagined should grow out of the flesh of a poor bird, and be renewed annually, for the sole purpose of fascinating his lady love. And here the question arises as to the capacity of the female for appreciating all this. It is, indeed, very difficult to believe that these birds can fully appreciate such perfect beauty as they are gifted with; for, even amongst mankind, the possession of a refined taste for the beautiful is a characteristic mark of the highest civilization.

How very remarkable is the fact that in birds of the ostrich tribe it is the males who hatch the eggs and rear the young! The females assuming the airs so characteristic of the males in all other known families. A fine female cassowary (*Casuarius casoar*) at the Zoological Gardens exhibits a most pugnacious disposition at breeding time, the beautiful colours of the naked skin of the head and neck being then very brilliant. The two wattles are much larger than those of her partner at this time, and on the least excitement the splendidly-coloured skin of the neck is extended downwards, and also considerably puffed out. Woe betide the luckless individual who comes within reach of the terribly-powerful inner-toe spurs of this enraged female!

Courtship being a very potent cause of war in the animal creation, the following account of a great battle will not be considered out of place here. It is extracted from "Land and Water" of Dec. 1, 1866:—

"In an Australian newspaper, the 'Menaro Mercury,' a detailed description of the habits of the lyre bird (*Menura superba*) is furnished by a correspondent, who is evidently very familiar with the bird. Mr. Gould, however, in his 'Handbook of the Birds of

Australia,' has given a nearly similar account, only that the following observation appears to be novel: 'During one of these rambles,' remarks the writer, 'I beheld a sight which, to me, was grand in the extreme. In working my way through the tedious scrub, and being upon the brow of a hill, making my way to camp, I heard a din in the valley below which completely astonished me. As I neared it, the noise became abominable, and I wondered what it all meant. Knowing the shyness of bush-scrub animals, I sneaked nearer the scene of noise, and came in view of as fine a sight as I have witnessed in all my life. About as near as I could guess, a hundred and fifty lyre-cocks were ranged in order of battle, and fighting with indescribable fury. So astonished was I, that I forgot to place my gun on full cock, and, in almost a second of time, they took alarm and disappeared, leaving me greatly disappointed.'"

Amongst the duck tribe, the mandarine (*Aix galericulata*) is a pre-eminently beautiful species, the male being very richly adorned, and possessing what may be termed specialities, the most remarkable of which are two very broad feathers in his wings, of a rich tawny brown colour, edged with white, black and glossy purple. During courtship these feathers are vertically elevated and retained in that position by the bird's beak, which is incessantly applied to them with a very peculiar jerking movement, at the same time uttering a note which has a remarkably *watery* sound. Like many of its congeners, all the finery of the male of this species is lost when the breeding-time is over, and replaced, for a few months only, by the sober browns and greys of the female. These birds are said to be regarded by the Chinese as emblems of conjugal fidelity, being often carried about in their marriage processions.

Thus much on this most fascinating subject, for such it is, although it has been strangely neglected by naturalists. There are yet numbers of highly-decorated birds whose modes of display have never yet been observed by human eyes; these remain as pleasurable objects to hope for and to observe when the opportunity occurs.

Coloured Plate.—The pinnated grouse (*Tetrao cupido*), showing in the distance a male having the neck-plumes pendant.

Plate II.—Male birds during courtship. *a*, Honduras turkey, *Meleagris ocellata; b*, Peacock pheasant, *Polyplectron chinquis; c*, Impeyan pheasant, *Lophophorus impeyanus; d*, Japanese pheasant, *Phasianus versicolor; e*, Australian bustard, *Otis Australasianus; f*, Bell bird, *Chasmorhynchus nudicollis; g*, Common partridge, *Perdix cinerea; h*, Golden pheasant, *Thaumalea picta; i*, Black grouse, *Tetrao tetrix.*

THE CACTUS FAMILY: CACTACEÆ.

BY JOHN R. JACKSON, A.L.S.,

Curator of the Museums of Economic Botany, Kew.

WITH DIRECTIONS FOR THEIR CULTIVATION

BY J. CROUCHER.

(*With a Plate*).

THE Natural Order Cactaceæ is a group of plants about which others than botanists or even horticulturists have some knowledge, for many of its members are well-known window plants, and the comparative rarity and beauty of their flowers cause them to be general favourites. The fact of plants of this order being not unfrequently seen as parlour plants takes away in some degree the wonder their peculiar forms would otherwise create. Nevertheless when seen together in a mass, as they are in the Cactus house in the Royal Gardens, Kew, their singular appearance never fails to arouse an interest mingled with surprise.

The variability of their forms, the showiness of their flowers, and the general absence of leaves, are all points noted by the general observer, but many of the small growing species, which might perchance be looked over in a collection like that at Kew, offer points of interest to the lover of nature as well as to the microscopist. The order essentially belongs to South America, from whence many of the species have been transported into various parts of the globe, one species of Rhipsalis, however, appears to be indigenous to Africa and Ceylon, and one to the Mauritius.

The order numbers, according to the latest revision, thirteen genera and about 950 species. They consist of fleshy or succulent plants of all sizes, some growing to the dimensions of small trees or shrubs; the stems are usually angular, but sometimes flattened or leafy. Their forms, however, are most variable, as will be seen by the plate, for while in some—*Cereus giganteus* for instance—the stems grow to forty or fifty feet or even higher, and often columnar in form, in others they are huge masses of succulent matter, almost or quite spherical. The flowers are for the most part large and showy. The sepals, petals, and stamens are usually indefinite, the two former often combining, and the filaments of the latter long and thread-like, tipped with anthers of ovate form. The fruits are fleshy, some of them of a refreshing sub-acid flavour, and others of a sweetish insipid taste, many of them are eaten by the natives in the countries

where they grow, nevertheless the order cannot be called an important one in an economic point of view.

In an order numbering so many species as this does, it would be impossible even to enumerate them all, nor is it perhaps necessary, as my aim in this article is merely to point out some of the principal peculiarities, and points of interest in the order, leaving those of my readers whose interest has been aroused by a perusal of this paper to follow out the subject more minutely by an examination of the plants themselves, or by reference to more elaborate and extended works.

In the genus Cereus some of the largest and most striking forms of the order occur, as well as the largest and most attractive flowers. The habits of the species vary considerably, some growing erect, others climbing up trees, while others trail along the ground, the forms of their trunks are also very variable, for while some are cylindrical, or perfectly columnar, others are angular, and others again are ribbed or furrowed. In the young state the stems are fleshy, but as they get old many of them harden and become woody.

The most noble of all the species, indeed of the entire family in point of size, is the *Cereus giganteus*, Engel. This plant is commonly found forty or fifty feet high, and sometimes even to a height of sixty feet with a diameter of two or more feet about half way up, lessening somewhat towards the top and near the base. These plants are frequently unbranched throughout their entire height; some, however, send forth branches from their sides, which grow at first almost at right angles, but afterwards start upwards, parallel with the main trunk, and maintain nearly the same thickness throughout. The stems and branches are deeply furrowed or ribbed, the ribs being arranged at regular intervals from each other, from the base to the top. On the edge of these ribs, at distances of about an inch apart, are small tufts of a yellowish colour, bearing numerous short spines, amongst which are five or six longer ones. These plants are devoid of leaves, like most of the other Cacti, and begin to flower when about ten or twelve feet high. The flowers, which are of a light cream colour, are composed of numerous petals, and sepals, and measure some four or five inches long, and when fully expanded are of nearly equal diameter. They are borne in profusion on the summit of the stems and branches. The fruits—which are about three inches long, of a green colour outwardly, having a scar at the top which marks the position of the fallen flower leaves—are composed of a mass of crimson pulp, in which are imbedded

numerous small black seeds. They are known by the Mexican name of Pitajaya and are very highly valued as an article of food by the natives in the districts where they grow. Being borne at the tops of the stems and branches they are out of the reach of ordinary fruit gatherers; the natives, however, rise to the occasion, by tying at the top of a long pole two pieces of stick so as to form a fork, by which means the fruits are brought down, and are afterwards collected. They are eaten either raw or made into a conserve, which is said to be exceedingly good, large quantities of molasses and syrups are also made from them, and kept for use during the winter season. Most of the birds and animals which inhabit the regions where these plants grow, are exceedingly fond of the fruits, and devour them greedily if they are allowed to remain upon the trees, which they seldom do long after getting ripe, for they soon burst open into three or four pieces curving backwards so as to expose the pulp and seeds to the action of the light and air, by which means the pulp is dried up, and the seeds are scattered.

These plants abound in the hottest and almost desert regions of New Mexico, rising like huge posts amongst the rocks and ravines, and actually growing in mere crevices or fissures, where it seems next to impossible for any vegetation to exist; in some parts indeed the country is almost a barren wilderness, so that these giant Cacti lend to the view a most singular aspect. "As far as the eye can reach in the valleys, or on the mountains, little else but rocky boulders, and the stately yet awfully sombre aspect of the *Cereus giganteus* can be seen." In all periods of their growth the plants present almost an equally singular appearance, for when young their form is nearly globular, becoming as they get older somewhat club shaped, and eventually rising to the heights we have mentioned. As the plants get old and fall into decay the pulpy or succulent portion to a certain extent dries up, the woody parts split and rend, and it so forms a curious skeleton of what was even in its health and vigour a curious tree. Some of the species of Cereus are celebrated for their splendid flowers, and for their peculiar habit of flowering at night, and it is not a little remarkable that these night-flowering kinds produce the most magnificent flowers of the whole genus, if not of the entire family.

Cereus grandiflorus, Haw., is perhaps one of the best known of these night-flowerers; it is a creeping plant, a native of the West Indies, scrambling over rocks or decayed trees; the branches are slightly angular, with five to seven angles. The flowers are very large when fully expanded, and cup shaped. The sepals are of a

deep yellow, or yellowish orange colour, and the petals pure white, the stamens are long and numerous, tipped with linear oblong anthers of a bright yellow colour. The stigma is also yellow, composed of many rays diverging at right angles from the style. The flowers are very fragrant, opening late in the evening, and becoming fully expanded about ten or eleven o'clock; they last only one night, and droop very early in the morning.

From its specific name of grandiflorus, one would be led to suppose that its flowers were larger and more splendid than those of any other species; this, however, is not the case, for another night-flowerer, *C. MacDonaldiæi* though, somewhat similar in the colour of the sepals, and identical in the pure white of the petals, produces larger flowers, which, when fully expanded are quite fourteen inches in diameter. This species is a very free flowerer. Its habit is similar to that of *Cereus grandiflorus*, having creeping dark green stems, about the thickness of a man's finger, but slightly angular, with five blunt, irregularly-placed angles. It grows very rapidly, throwing out its long straggling branches in all directions. A fine plant exists at Kew, which flowers freely during the early summer months. The next plant in point of magnificence amongst the night-flowering series is *C. triangularis*, this species is so named from its triangular stems, which are perhaps slightly thicker than those of the last-named species, but the plant has a similar creeping habit, and bears very large yellowish flowers. A good plant of this species is also amongst the Cacti in the Royal Gardens, Kew.

Cereus Lemairei, *C. pterogona*, *C. nycticalus*, and *C. rostratus*, are all night-flowerers, indeed the whole of the true Cerei open in the evening, and most of them are closed by about eight o'clock in the morning; the temperature of the house in which they are grown, however, exercises a great influence on them; if the air is hot and dry the flowers last but eleven to fourteen hours, while in a cooler atmosphere they will last twenty hours.

The species already briefly described, have been examples of the tall or columnar, and of the creeping or trailing kinds. *Cereus Tweediei*, H.R., is a small growing plant, cylindrical in form, and furrowed or ribbed, bearing on the edges of the ribs numerous spines, four or five of which are longer and stouter than the rest. It flowers freely, the flowers are of a rich orange crimson colour, and these, when contrasted with the dark green of the stem, produce such a pleasing effect, as to make the plant one of the prettiest of the family.

Cereus chilensis (see Plate, Fig. 16) is, as its name implies, a native of Chili; it is an erect growing plant, very evenly furrowed or ribbed, the ribs not sharply angled as in many of the species, but the face of each one is rounded, and the spines set on with the greatest uniformity, the longest, thickest, and most prominent starts from near the centre of the mammillæ pointing downwards; in a direct line with it is a shorter one pointing upwards; the spaces between these being filled on each side with five others alternately long and short, two, however, being longer than the other three, the length of the corresponding spines on either side are equal.

Under the generic name of Pilocereus, some botanists have separated a few species from the genus Cereus; the differences, however, are of so little importance, as to be considered by the most recent botanical writers, as not sufficient to constitute a generic character. The chief differences are in the flowers being smaller, and their parts not so numerous, while the stamens are connected to the whole surface of the tube. The upper portion of the plants, also are covered with long shaggy or woolly hairs or spines; and the spines themselves, which cover the lower portion of the plants, are more numerous, and are also longer and finer. The species are natives of Mexico and tropical America. The most characteristic and striking in appearance is the Old Man Cactus. (*Pilocereus senilis*) (see Plate, Fig. 10), which attains a height of from twenty to thirty feet, with a diameter of nine to ten inches. It grows perfectly straight, is fluted or furrowed by narrow channels from the base to the very top. The ridges of the ribs are covered with tufts of spines placed very closely together, and surrounded with long white hairs; near the top these hairs are thicker and longer, indeed they hang down to such a length, as almost to hide the upper portion of the stem, and so give to the plant a really venerable and hoary aspect; it is owing to this appearance that the plant has received the common name of Old Man Cactus, as well as its specific name senilis.

Many of the Cacti are noted for their tenacity of life, and the following instance is a good illustration of this peculiarity. A plant of *P. senilis*, which was growing in the Cactus house at Kew, and which actually got too high for the house, was removed to the new temperate house; the process of removing such a bulk of fleshy matter was, as might be expected, no easy task, especially when we consider the extreme sharpness of the multitudinous spines, so the plant got slightly fractured across its trunk, within eighteen inches

or two feet of the top. After remaining a short time in its new home, it showed signs of dying, and in fact, continued to blacken rapidly from the base upwards; it was sent to me to add to my museum specimens, and I had it placed in a dry brick building. The stem which had for the most part decomposed and turned black, continued to do so till it had reached the fracture, from which the upper part instead of mortifying as its lower extremities had done, not only retained its bright green colour, but even took a still brighter green at the apex, by pushing forth a new growth. When young, the stems of these plants are very fleshy, and appear outwardly like a solid mass of green succulent matter; as the stems get older, however, an immense quantity of oxalate of lime is formed in them, so much indeed, that if a stem is dried and a section made across it, the grains fall out like so much sand, leaving only the outer cuticle with the spines attached, and the ring of wood which is formed of separate wedge-shaped masses, and situated at about an equal distance between the centre and the circumference of the stem. This was the case with the lower part of the specimen just mentioned, while the upper part had formed roots of its own, which had struck down into the decaying vegetation and oxalate of lime, and so made a fresh start in life. Other species of Pilocereus are shown at Figs. 9 and 11.

Echinocereus is another genus which is so closely allied to Cereus as to be by some authors united with it. Between twenty and thirty species are enumerated, the plants of which are all small, about a foot or so in height, with either simple or branched stems, some of which are divided into numerous ribs or ridges, while others have few, some only four; these ridges are very strongly armed with sharp spines. The tube of the flowers, unlike most of the other Cerei, is very short. The fruits of some of the species are eaten by the natives of Mexico and Texas, where they grow, and they are said to have a flavour somewhat resembling that of a gooseberry. The fleshy part of the stems of some of the species is also said to be eaten and highly commended as a vegetable; the spines, however, have first to be very carefully removed.

The genus Echinopsis numbers between twenty and thirty species, all natives of Chili, Bolivia, Mexico, Brazil, and Texas; they were formerly included in the genus Echinocactus, but from the position of the flowers being at the side of the stem, and not at the top as in the latter genus, together with some minor botanical characters, modern authors have placed them with the Cerei.

Echinopsis multiplex will serve as a representative of the genus.

It is a plant of nearly globular form, with sharp angled parallel ribs, and groups of spines arranged along these angles; there are from ten to twelve spines in each group, the central one thicker and longer than the rest. The flowers are very large in proportion to the size of the plant, for while the stem may be not more than six or eight inches high and five inches broad, the flower itself is often as high as the plant, and its diameter as great as its length. The colour is a rose pink inclining to a deeper tint near the apex of the petals.

Two other species of Echinopsis, *E. formosa*, and *E. Pfersdorffii*, are shown in the Plate at Figs. 1 and 27, and Fig. 3.

Echinocactus is a genus of some interest, not only on account of the large and showy flowers of its various species, but also on account of the grotesque and usually globular form of the plants themselves, the stems of some, however, are cylindrical, and others are of an oblong shape, but all are more or less deeply ribbed, some of the ribs being broad with round edges, and others acute with sharp edges, upon which tubercular swellings are frequently formed, and in some species are very largely developed, most of them bearing sharp and very stiff spines arranged in uniform clusters, and often surrounded at their bases by little woolly tufts. The head quarters of the Echinocacti, like the bulk of the whole order, is in Mexico, more than half of them being found in that country, and the rest in different parts of South America; they love hot and stony localities where they get little rain, and are exposed to the full effects of the sun. They bear large and showy flowers, composed of several rows of floral leaves, the lower or outer sepals having a simple scale-like appearance, and the upper ones appearing by an almost imperceptible transition to pass into petals. The inner petals are more spread out or radiating, and the stamens are shorter than the petals, are indefinite and are united to the tube of the calyx. The stigmas are five to ten in number, and radiate from the top of a column-like style. The flowers are produced at, or near the top of the plant springing from the upper side of the younger bundles of spines. The fruits are mostly prickly. Perhaps the largest and most interesting species is *E. helophorus* (*E. visnaga* of some authors), see Plate, Fig 20. It has numerous close, sharp, parallel ridges, with clusters of spines arranged along their edges at short distances from each other; so numerous are these spines that a comparatively small plant in the Cactus house of the Royal Gardens, Kew, some time back, was computed to have upon it not less than 17,600, while a larger specimen in the same house

had as many as 51,000. These spines are very long, sharp, and stiff, and are constantly used by the natives for tooth-picks, and are said to be very durable. Probably the largest plant of this species ever introduced to this country was one received at Kew some years ago, it weighed one ton, and was nine feet in height by three in diameter. This plant, however, did not live long after its introduction.

Echinocactus cornigerus (Fig. 6) has a very singular appearance, being almost entirely encased in spines. The central one of each group is very broad, flattened and deflexed, and is very strong. Other species—as *E. electracanthus*, *E. Pfiefferi*, and *E. ornatus*, are shown in the Plate at Figs. 4, 13, 21, and 23.

Melocactus is a genus numbering about 30 species, growing in Mexico, Brazil, New Grenada, and the West Indies. The species are mostly globular with more or less prominent ribs, the edges of which are densely clothed with long, stiff spines, each tuft being placed at very regular distances, the small flowers are buried in a mass of woolly hairs, and fine spines, and are arranged in a cylindrical or hemispherical head at the top of the plant. The Turk's Cap Cactus (*Melocactus communis*, Fig. 8) is a well-known species, being frequently seen in cultivation in this country. It covers large tracts of land in South America and the West Indies, seldom growing more than two feet high. Owing to the arid nature of the districts in which the plants grow, it is said that the mules, after removing the spines with their feet, suck the juice or water which the plants contain, for the purpose of quenching their thirst.

The common name of Turk's Cap Cactus, is derived from the resemblance to a Turk's Cap of the red coloured cylindrical flowering portion.

The genus Mammillaria is not only a very large and interesting one, but it also contains a great variety of forms, as will be seen by reference to the Plate. The genus derives its name from the fleshy tubercles or mammillæ which cover the whole stem, and which are arranged in a spiral form, varying, however, considerably in size in the different species. It is from the presence of these mammillæ, that the members of their genus are readily known from their allies. The flowers, which are of different colours in the several species, some rose-colour, others white, and others yellow, are borne near the tops of the plants, and are arranged in a transverse zone, each flower being sessile at the base of the mammæ.

Unlike those of many of the Cerei, they open in the day and close at night. The fruits are obovate and berry-like, and contain a

number of small seeds. The species abound in Mexico, but some are found in Southern California, Texas, and Missouri, on the north; Guatemala, on the south, and even down to Buenos Ayres and Chili.

The plants are usually small, but the forms which they assume are most varied; some appear to be composed simply of a series of small, green, fleshy mammillæ, each having almost the appearance of an individual plant, and each being crowned with a tuft of spines; others again appear like squat masses of vegetable matter, rising but a few inches high, composed of numerous mammillæ covered with small star-like spines, most beautifully and uniformly arranged. *M. pusilla* (Fig. 2), is one of this description, and a prettier little plant it is difficult to find, both by reason of the beautiful and delicate arrangement of the spines, the yellow and rose-coloured flowers, and the small bright crimson berry-like fruits, which succeed them. *M. densa* (Fig. 22) is another of similar character, the mammæ are, however, rather larger, while in *M. elephantidens* they are larger still, and are partially divided longitudinally by a deep depression, the apices are crowned with six or seven radiating spines. Many other species having a similar spreading habit, are equally interesting and beautiful, but space will not allow me to mention them.

Perhaps the tallest species of the whole group is *M. coronaria*, which is one of the cylindrical growing forms, and though in collections we seldom see it more than twelve inches high, it is said to attain a height of five feet; it has crimson coloured flowers and the spines are very uniformly arranged on the mamillæ, being seated in little tufts of white woolly hairs. *M. crucigera* (Fig 14) is a very pretty plant, having at the tips of its mammillæ four radiating spines springing from a white wool-like cushion. *M. Parkinsoni* (Fig 18) is another of the cylindrical forms, having long sharp white spines tipped with a reddish brown tinge. In *M. dolichocentra* (Fig 26) the mammillæ are long and distinct, capped with four long white spines, not radiating as in most of the species, but pointing outwards almost in a direct line with the mammillæ. *M. acanthophlegma* is a most beautiful little plant, the mammillæ are small and somewhat pointed at the apex, which is crowned with a delicate series of star-shaped hairs surrounding the small spines. Other species of Mammillaria are shown in the Plate, to which I must refer my readers, as, before closing this article, a few words must be said about the Opuntias, which genus in an economic point of view is certainly the most valuable of the entire family, for it is from one or more species of Opuntia that the cochineal insect derives its food.

About 150 species have been described, but it will be utterly impossible to mention even a tithe of them. The fruits of many are eaten under the name of prickly pears, and may sometimes be seen exposed for sale in the streets of London, some are mucilaginous, and very insipid, while others have a refreshing and agreeable flavour. They are more or less egg-shaped or pear-shaped, are covered with tufts of small prickles or spines, and at their apex bear a large scar denoting the position of the fallen flower leaves. They consist of a fleshy pulp enclosing numerous small seeds.

The species abound chiefly in Mexico, California, Brazil, Peru, and Chili, a few being also found in the West Indies, and some have become naturalized in various parts of Southern Europe. The plants, which are mostly fleshy, becoming woody as they get old, are either erect or decumbent; the stems and branches are frequently jointed, and mostly flattened; some, however, have unjointed, cylindrical stems; they seldom grow to a greater height than ten or twelve feet. *Opuntia tuna*, is perhaps the tallest growing of all the species, attaining sometimes the height of twenty feet and forming a woody stem with jointed branches; the spines are long and stiff, and are arranged at distant intervals in bundles of from four to six each, the flowers are of a reddish-orange colour, and are composed of numerous sepals and petals, gradually passing one into another and so undistinguishable. The native habitat of this species extends from Mexico to Quito, but it is also found in the West Indies, and has long been naturalized in Southern Europe, Northern Africa, and Madeira. It is one of the species extensively cultivated in Mexico for rearing the cochineal insect. The fruits are edible, and when ripe they contain an abundance of sweet juice of a rich carmine colour which is used in Naples for water-colour drawings. In the West Indies it is used to colour confectionery, and in Mexico a favourite beverage is made from it. It is from this rich coloured juice with which the plants abound that the cochineal insect derives its commercial value.

Opuntia cocinellifera—so called from its being a cochineal-bearing species—is largely cultivated for this purpose, it is, however, now separated from Opuntia, and placed in the small genus Nopalea. Whole plantations of these Cacti exist in Mexico, New Grenada, and the Canary Islands; the bulk of our imports, which amount to over 2,000 tons annually, and which realise a price of about £400 per ton, being obtained from the two last-named countries. In the cochineal plantations, which are called Nopaleries; the plants are grown in rows, and are not allowed to attain more than four feet in

height. The insect which feeds upon these Cacti, and of which countless millions are collected and imported into this country every year, is known to entomologists as the *Coccus cacti*, of Linnæus. The female insects are placed upon the plants usually about the month of August, this operation being called sowing; they breed very rapidly, and the young insects grow so fast that in about four months the cochineal harvest commences; this is effected by brushing the insects off the plant into a vessel, they are afterwards killed by immersing them in boiling water, or exposing them in heaps to the sun, and when dry they are ready for exportation. Many qualities are known in commerce, and it seems that the market value is much affected by proper care in the process of killing and drying. The uses of cochineal, and its importance in the arts and manufactures, are well known. Plants, with the insects upon them, are to be seen in the Cactus house at Kew.

As I have before said, the general habit of the stems of the Opuntias is jointed, without any apparent centre of growth, but in *O. brasiliensis* we get the truly arborescent character—a cylindrical stem with regular branches. In the old branches and stems of some of the species, as *O. tuna*, a large quantity of net-like woody tissue is formed, which has been made into various ornamental articles, as flower-baskets, vases, and trays, etc., a collection of which is in the museum at Kew. The spines of the Opuntias are exceedingly sharp, some of them, as *O. spinosissimus*, being minutely barbed, not only at the point but for some considerable distance up the sides, so that if it happens to penetrate the flesh ever so slightly, it requires a much stronger pull to free it than would be supposed. Some of the species are tolerably hardy, and not long since *Opuntia rafinesquiana* was advertised as a new garden edging plant. In the genera Rhipsalis and Pereskia we have plants differing in general from the rest of the Cacti, in the former the plants are small, fleshy, jointed, and leafless, some having long cylindrical stems looking like mere green cords, others angular, and others leafy, while in Pereskia the plants have leaves, some being cylindrical, and others broad, flat, and veined. The remaining genera of the order are chiefly of botanical interest alone, and I must therefore pass them over.

I have been compelled in the foregoing pages to be as brief as possible in my notice of these interesting plants, and have endeavoured to draw especial attention only to the most interesting species. The extent of the order precludes anything like a full description of the individuals in the space of one paper, and, more-

over, I thought it would enhance the interest of this article to append to it some practical hints on the cultivation of Cacti, which has been kindly supplied to me by Mr. Croucher, the foreman in charge of the extensive collection at Kew. I am also indebted to my friend Mr. W. Warwick King, an excellent amateur photographer, for a very accurate photograph of a selected group of plants in the Cactus house at Kew, taken expressly for this paper, and from which the plate has been prepared.

THE CULTIVATION OF CACTI.

BY J. CROUCHER.

Cultivation of Cacti.—In written instruction on the cultivation of any class of plants, there are many points of detail one can scarcely put into words; which points must be learned by observation in practice; but the general conditions of success may be, such as composts, temperature of house, propagation, time and mode of potting, etc., which instructions, if well followed out, will be sure to lead to good cultivation.

The majority of the genera are sun-loving subjects, and as a consequence the first thing to be taken into consideration, is to get your house so situated as to ensure the greatest amount of direct light, the best aspect will be due south; a lean-to house is the best, with good clear glass, to which the plants must be as near as possible; the genera Epiphyllum and Rhipsalis, are exceptions to this rule, and prefer a little shade in the summer, as they mostly grow in the forests, but in any house there are always some parts more in the shade than others; the plants are not damaged by the sun but will grow more luxuriantly in the shade. It is not easy to get the house too hot for Cacti in the summer, but they will thrive well in a temperature of 60° to 80° with sun, and in winter the majority will bear a minimum of 40° with dry air; though the genera Rhipsalis and Epiphyllum must be kept at 55° to 65°, or they will protest by looking very yellow. Most of these plants being natives of those parts of America lying south of the equator, they, as a consequence, get their warmest season when we get our coldest, which gives them a tendency to grow during our winter; and a predilection for rotting if not kept perfectly dry. As above stated, the whole of these plants being American, they should not be repotted in early spring, as is the common practice; which practice seems to have originated from the fact

of most plants starting into growth on or about that time. I have often thought, that if amateurs and gardeners were to think more on this subject, they would at once see the folly of supposing that all countries had their spring at the same time as we have in England; it matters little with most persons if the plants come from East, West, North, or South, they must be potted in our spring; and as the plants will not grow out of their season, the soil gets stale, and when the roots do begin to grow, they find the condition unfavourable, and the result is stunted growth, and sometimes death; not through a wrong compost, but unseasonable potting. The potting of Cacti should be left until June or July, when they will be on the point of starting into growth. The best compost is loam, with silver sand and broken bricks, the quantity of sand must be regulated by the stiffness or otherwise of the loam; the object being to make the whole sufficiently porous for the water to pass through freely; as a rule one gallon of sand to three bushels of loam, and one bushel of finely broken bricks will suit for the genera Opuntia, Echinocactus, Echinopsis, Cereus, and Mammillaria; for Epiphyllum and Rhipsalis, a mixture of rough peat and loam, with a little sand and rough crocks, is the best. Such as *R. cassytha, funalis, saglionis,* and *mesembryanthoides* may be grown on pieces of fern stems, in baskets or pots suspended the same as Orchids, and very interesting objects they make; *Cereus flabelliformis* and *leptopes* succeed best suspended in a pot, with the ordinary soil; *C. grandiflorus, Macdonaldiæi,* and the other night-flowering species, grow best planted in the back border of a stove with a tolerable amount of moisture in the air; it is not necessary to give them much soil, as they get most of their nourishment from their aerial roots. When the plants are to be potted, the whole of the small fibres of the roots should be cut off; this is a very particular point in the cultivation of this class of plants, as it enables you to get the plants into small pots, and if left on they decay, and so do more harm than good, by making the soil impure; amateurs as a rule are very shy at cutting the roots from their plants, but a good cultivator of Cacti has not the least hesitation about the subject, and it is probable that they lose most of their fibrous roots during the dry season, in their native habitat; the soil should be made quite firm in the pot and well drained, taking care to put enough rough pieces of soil on the drainage to prevent the soil from getting amongst it, and so defeat the object for which it is placed there. Manure should be specially avoided, as it will cause the soil to get charged with impurities, with the least excess of water, which impurities the plants will take up,

and though they may look green and healthy, may some day be found quite dead; some persons recommend manure, but after sad experience, I say away with it. I also know persons who grow their plants in nearly all manure, but they are grown for sale, and their profit consists in the death of the same. Others again recommend lime rubbish being mixed with the soil; which practice has originated from the fact of oxalate of lime being found to constitute a great portion of the substance of these plants, but lime rubbish from the debris of old buildings is very different from that found in the natural soil of the plants, and the effect on the roots is to cause them to become stunted, and what horticulturists call clubbed; therefore my advice is, if you want your plants to grow well don't use lime rubbish.

When the plants have been potted they should be kept without water until they show signs of growth; never mind if they don't ask for it until two or three months after potting; don't give it them until they do, for they always contain enough moisture to enable them to start, and until that start is made, the roots have not begun to grow; when the plants have started into growth they may be watered about once a week, for the first month; after that twice, with a good syringing every other evening before shutting the house. This treatment may be continued until the end of August, when the syringe must be laid aside; after September, the watering must not be oftener than once in fourteen days; from October till March, the genera Mammillaria, Echinocactus, Cereus, and most of the Opuntias must be kept quite dry. As the Phyllocacti flower in the early spring, they must get water about once a month during the winter. Epiphyllum and Rhipsalis may be moderately dry, but they will not endure so much drought as their more succulent allies. It is not necessary to pot the plants every season, as they like to be pot bound; some do well in the same pot for five or six years. Should any plant be found to have lost its roots, or show signs of decay, the infected part should be cut clean out at once, and the plant turned up to the full power of the sun, till it begins to show fresh roots, when it may be repotted, and watered with care; this rule of turning the plants up to the sun should be especially attended to with newly imported plants, as they require all superfluous moisture cleared from them; their roots should be cut off, as when dead they act like string, conducting moisture to the plants; to the neglect of cutting off the dead roots, I attribute the many failures to grow the Turk's Cap cactus (*Melocactus communis*), although this species evidently does not increase in size after

forming the cap or flowering point, yet it may be kept alive some years.

MODES OF PROPAGATION.—The genera Rhipsalis, Phyllocactus, Cereus, and Opuntia are easily increased by cuttings, which should be taken off in May, and laid in the sun until rooted, when they should be potted and watered carefully, though Rhipsalis, and Phyllocactus may be potted at once, and kept dry about fourteen days, when they will be rooted and may be watered; Echinocactus and Mammillaria must be increased by offsets; Echinocactus requires the top to be cut off, which must be exposed to the sun until rooted, the old plant will throw out young ones which may be taken off the next season; as a rule the Echinocactus is slow in throwing offsets, and care must be taken not to let the plant get any water until it shows signs of doing so; patience is a virtue in great demand in the propagation of this section of the order. The slender growing species are often grafted on stronger and faster growers, though care must be taken not to select for a stock one as celebrated for vigour as the scion is for want of it, or your labour will be in vain; as a stock for the smaller growing Echinocacti, *Cereus tortuosus*, or *colubrinus*, are the best; for the larger, *C. peruvianus*, and *gemmatus*. In grafting, care must be taken to cut the two ends rather convex, than concave, as they are apt to shrink a little, which would cause a separation, and so spoil the graft; the scion must be tied firmly to the stock, taking care that the edges meet, or at least one of them; the best plan to ensure against accidents is to put three sticks into the pot, and tie them together above the plant, thus causing a continual pressure from above. In grafting *Opuntia clavarioides* you may cut a cuneiform notch in the stock, and cut the scion to fit tightly, keep them firm with a stick on each side, and a thorn run through the graft. Some of the smaller species of Cereus, as *C. tuberosa* may be made pointed, with a corresponding hole in the stock; in all cases taking care not to disturb the plant when once grafted. When the operation is finished, the plant must be put into a close frame, or the shadiest part of the house, until it is out of danger. Epiphyllums are generally grafted, but not necessarily. The common stock used is *Pereskia grandifolia*, and *Blea*, but *Cereus speciosissimus*, and *triangularis*, make very good stocks, these plants being stouter, and more in proportion to the scion, though Pereskia stocks are more to be depended upon than Cereus. Cuttings of Pereskias intended for stocks should be put in in spring, selecting the young straight shoots of the previous season, about six inches long, or according to fancy; about September is the best season for grafting Epiphyllums.

The scion should consist of one or two joints; cut the outer bark off about one inch on each side of the scion, split the stock about the same length, put the scion in, and tie or pin it with a thorn, according to which stock you use; the plants must then be put into a close frame, and laid on their sides until united, which they will do in about six weeks, when they may be stood upright, and gradually hardened off. Most of the species may be raised from seed, which should be sown as soon as collected, if possible, and put into a temperature of 60°. The young plants grow very slowly at first; when potted off they should be placed near the light; it is best to let them remain in the seed pot until the following season, as they are very apt to damp if they are potted off to soon. Seed collected abroad should be left in the pulp, which being its natural protector prevents the air acting on it, and drying it up; packed in a small tin box it may be sent any distance without losing its vitality. The best flowering varieties are *Cereus speciosissimus*, and its varieties, as *C. Ackermanni*, *Jenkinsoni*, *splendens*, and others; these are the forms most commonly grown in cottage windows; the genera Phyllocactus, and Cereus produce many fine flowering varieties.

HYBRIDISATION.—This may be performed by any person, as the stamen and pistils are so very distinct, and the pollen produced in abundance; which may be preserved for some time, if kept in a bottle hermetically sealed. I have not met with any successful attempt to cross Mammillaria with Echinocactus, or Opuntia with Cereus, though I know of no cause why they may not be, as the differences in the flowers are not differences of structure, but merely degrees of development; such as a greater or lesser number of stamens and petals, or in the absence in some, and length in others of the tube of the corolla, excepting that it may be that the pollen tubes might be too strong for the distance they have to grow from the apex of the stigma, or vice versa.

The chief points to be observed in the above directions are, the light, time, and mode of potting, taking special care not to be afraid to cut off the roots. The watering which should be given with a rose on the pot; when given, let it be enough to thoroughly soak the soil; it is best to hold the pot as high as you can so that the water may fall on all parts of the plant, which serves the double purpose of washing and watering at the same time. Be sure to give them a good drying in the winter, upon which depends the success in flowering them the next season.

Some few species as *Opuntia vulgaris*, and *Rafinesquiana*, and *Echinopsis Eyriesii* are hardy in the south of England, and I have no

doubt that many species of Opuntia and Echinopsis would do very well in cold frames in winter and the open air in summer. For an amateur the Cacti are the best class of plants to cultivate, as they offer the greatest scope for number of species, and require so little attention. In a house 20 feet by 12, from 400 to 500 species may be grown; in the summer the house can be left night and day with air, and if the owner had no person he could trust, he might lock the house and leave them a week at a time without fear of harm; in the winter, if he should be obliged to leave home, the only thing would be to get the heat looked after, and his pets would welcome him home with as fresh an appearance as when he left. One often hears the remark from some person who has been disappointed—I bought some in the market, but they soon died; the fact is these plants are newly potted, and should be treated as advised for fresh potted plants. Cacti intended for exportation to long distances should be laid in the sun until they begin to shrivel, when they should be packed in some coarse material, as straw, taking care to use enough to prevent the spines of one piercing the other, for if one begins to rot, the whole will become moist, and endanger the whole cargo; holes must be made in the sides of the boxes to cause a current of air to pass through, as a safeguard against accident.

ANIMALS AS FELLOW-BOARDERS.

BY P. J. VON BENEDEN.

M. P. J. von Benéden recently read a paper before the Belgian Academy on what he termed the *commensalisme,* commensiolity, or, literally, *common-tableism* of animals, describing the habits of creatures who may be said to board together, but whose association is distinct from that of victim and parasite.

Every fish, he says, is a living and moving territory, on which a fauna is developed possessing special interest. When a small animal claims to profit by the fins of one larger than itself, accompanies it in its chase, and picks up spoils which the larger one disdains or abandons, we see none of the motives which characterize parasitism. Even when one resides upon the other, it frequently does not deserve the term which is applied to it. It is not rare to find loyal companions by the side of generous hosts, rendering service in return for the hospitality they receive. The parasite makes it his business to live at the expense of another; the associate is simply a table companion. When a whale is covered with barnacles, who can say that these Cirripeds are parasites? They merely ask of their colossal companion a lodging-place, and they are not more dependent upon him than coach travellers or railway passengers: they feed themselves on their journey. Leeches behave quite differently: temporarily attached to the skin of their host, they suck his blood, and drop off after their meal that they may conveniently digest it. They are not deemed parasites, because they leave their host during the intervals between their meals; but this is an erroneous opinion, for they are true parasites, as the barnacles are true companions.

There are many animals living in common whose relation to each other is not well appreciated, and it will not be uninteresting to glance at these, and endeavour to form a notion of the ties that unite them. We do not mean to speak of those associations which are known as flocks and troops, composed of individuals of the same species united for defence or attack; or of different sexes, neuters, workers, soldiers, etc., which belong to the same family. Our purpose is with associations of different species whose members bring together their energy, their intelligence—I might say, their capital, and become fellow-boarders, living on terms of perfect equality; although it is not uncommon to see the strong use up the

weak, or the evil-disposed slip in amongst peaceful communities. The sea-bed has its bravoes and *fiers-à-bras.*

Amongst fellow-boarders we see some that preserve all their independence, and who, at the least cause of discontent, break the connection, and seek their fortunes elsewhere. They are recognized by their apparatus for fishing and travelling, which they never put aside. Others instal themselves upon their neighbours, throw away all their travelling-gear, make themselves comfortable by a change of toilet, and renounce for ever their independent life. Their lot is fixed to the creature that carries them. They are permanent fellow-boarders.

Let us consider first,

FREE FELLOW-BOARDERS.

We find free fellow-boarders in different classes of the animal kingdom. Sometimes they sit on the back of a neighbour; sometimes they go in at his mouth, and follow the route of his food; and sometimes they take refuge under his cloak. An interesting instance belonging to this first category is afforded by the graceful fish, the *Donzella,* which makes its abode in the body of a *Holothuria.** The Donzella is elongated like an eel, and so compressed that it has been compared to a sword. It is found in different seas with precisely the same habits. The fish lodges in the digestive cavity of its companion, and, without regard for the hospitality it receives, takes its share of everything that enters. It makes use of a generous acquaintance, who can collect food better than itself. The *Holothuriæ,* or sea-cucumbers, are excellent fishers, and we often find in them, side by side with the Donzella, who are probably gluttons, prawns and pea-crabs, who come for their part of the spoil. My friend, C. Semper, has seen sea-cucumbers in the Philippines who were not bad imitations of an hotel furnished with a *table d'hôte.*

In the Indian seas a fish is found known as *Oxibeles lombricoides,* modestly lodged under a star-fish (*Asterias discoides*), and taking advantage of its fishing powers. In Brazil a Siluroid, of the genus *Platystoma,* a clever fisherman, thanks to his numerous lines, lodges very small fish, which were for a long time supposed to be its young. It was thought the female kept her young in her mouth, as the marsupials keep their infants in a pouch; but it is now known

* In a note, M. von Beneden says naturalists have long known these fishes as *Fierasfers.* They are allied to (*voisins*) Ophidium, eel-pout or barbolt, and sand-eel—fishes which are very dissimilar. It is the sand-eel particularly the Donzella is said to be like.—ED.

that they are adults and completely developed, but instead of living by their own labours, they prefer to lodge in the mouth of a good-natured neighbour, and take tithe of the food that comes in. This little fish has received the name of *Stegophilus insidius*. We see that in the animal kingdom it is not always the big which make use of the little.

Dr. Bleeker, an able naturalist who has rendered good service to science, makes us acquainted with an association of a still more remarkable character—that of a Crustacean who makes use of a fish—the black *Stromatée* of the Indian seas lodges in its mouth a *Cymothoa*, who, if not well adapted for catching his prey in a free state, is perfectly organized for swallowing what comes to him in this position. In the China seas Dr. Collingwood found an anemone not less than two feet in diameter, in whose interior lively little fish resided, the name of which he did not know; and without quitting our shores we may observe an elegant jelly-fish (*Chrysaorà isocela*)? sheltering many young scad (*Caranx trachurus*), which surprise us by swimming out from the body of their host.

It is, however, amongst the Crustaceans that we shall find the most remarkable examples of free fellow-boarders. The Crustaceans comprise lobsters, crabs, cray-fish, and legions of small animals who act as the sanitary police of the shores, and purify their waters of organic matters that would otherwise corrupt them. They are not like the insects, variegated and glittering in colour; but their forms are robust and diverse, and they often please by some special attraction. Amongst these Crustacean free-boarders one of the most interesting, though one of the least, is that tiny crab, the pea-crab, which lives in mussel-shells, and has been wrongfully accused of injuring the quality of their hosts as food. They have been very numerous this year, but cases of mussel-poisoning have not been more common than usual, and when such effects occur, it is the mussels themselves that are to blame. They produce a bad effect on some persons by idiosyncracy—we know the word though we do not know the thing.* For what reason do these small crabs, the *Picnotheras* of naturalists, which are not found elsewhere, inhabit these bivalve mollusks? The ancients, who knew the pea-crab of pinna, thought that the mollusks having no eyes were glad to avail themselves of the good sight of the crabs. These, like other Crustaceans of the same rank, carry on each side

* Particular mussels often produce poisonous effects on persons with whom this species of food usually agrees. This probably arises from a particular state of the mollusk rather than of the person they injure.—Ed.

of the carapace, at the end of a moveable support, a charming little globe, furnished with hundreds of eyes, which they can direct, as an astronomer turns his telescope, to any part of the firmament. What cannot be doubted is, that the little intruders live on good terms with the mussels, and if the latter supply a convenient and safe lodging, they on their side profit largely by the morsels which fall from the claws of their guests, who are well placed and well provided with prey-catching apparatus. Snugly seated in their living house at the bottom of the sea, they possess a moveable lair which the mussel carries about, and they can choose the best moment for attack, and fall upon the enemy unawares.

Pea-crabs are found in all seas, and in a great number of bivalve mollusks; the North Sea even containing a large sort of mussel, *Modiola papuana*, found in deep and difficultly-accessible spots, which always contains a couple of pea-crabs as large as a hazel-nut. The great avicala (*Avicula margaritifera*) which furnishes the oriental pearls, also lodges pea-crabs of a particular species, and it is not impossible that these creatures, and similar fellow-boarders, contribute to the formation of the gems, since these objects, so highly prized for feminine decoration, are only the results of vitiated secretions, most often produced by wounds. We have opened hundreds of these Aviculæ, and have never found them destitute of their crabs, many of which we placed long ago in the Museum of Natural History in Paris.

We also find pea-crabs in the great clams *Tridacna gigas*, whose shell might serve for a *bénitier* in the churches, and no doubt they would be discovered in many bivalves not yet considered.

On the coast of Peru there is a little crab which lives under rather different conditions. He chooses not a bivalve mollusk, but a sea-urchin, lodging in its anus, ready to seize any creature who may be attracted by the excreta. There is likewise a small crab, *Hopalocarcinus marsupialis*, which dwells amongst the depths of the thick branches of a coral found in the Sandwich Islands, and is at last completely enclosed in the dividing stems.

An association of a different kind, and the nature of which is difficult to appreciate, is that of a little crab, the turtle crab of Brown, found in the open sea on the carapace of sea-turtles, and sometimes on sea-weed (*fucus*). The sight of this crab is said to have given confidence to Columbus eighteen days before his discovery of the new world.

Amongst all the cases of companionship none are more remarkable than those of the soldier, or hermit crabs, so abundant on our

coasts. These creatures, as is well known, are decapod Crustaceans, somewhat resembling miniature lobsters, who make their abode in deserted shells, and change both their skin and their dwelling as they increase in size. The young ones are contented with very small habitations. The shells they inhabit are derelicts they find at the bottom of the sea, and in which they conceal their weakness and personal disadvantages with obstinate persistence. These creatures have too soft an abdomen to confront the dangers they encounter in their incessant wars, and the shells in which they thrust themselves supply at once lodgings and shields. Armed thus from head to foot the soldier crab marches proudly against his enemies, and fears no danger, because he has a secure retreat. But this soldier, or hermit crab, is not alone in his dwelling. He is not an anchorite like those dwelling in air, for by his side a worm is commonly installed as fellow-boarder with him, forming one of the most remarkable associations which is known. The companion worm is elongated like all the Nereids, and its supple undulating body is armed along its sides with bundles of lances, pikes, and daggers, the wounds from which are very dangerous. The crab, ensconced in his borrowed armour, and flanked by his terrible acolyte, attacks all he finds before him, and knows no reverse. Thus around his domain we observe a prosperity not seen elsewhere, and on his shell there usually flourishes a whole colony of Hydractinia blooming like a flower-bed, and inside we often find Peltogaster, Lyriope, and other Crustaceans who convert it into a true pandemonium.

On the English coast is another soldier crab, who has for his principal fellow-boarder a sea-anemone, the *Adamsia palliata.* This connexion is remarkable on many accounts, and especially for the good understanding which subsists between the crab and his attendant. Lieut.-Colonel Stuart Wortley has not hesitated to pry into the domestic life of these creatures, and this is what he says about them. The hermit crab never fails to offer the best morsels of his captures to his neighbour, and frequently inquires during the journey if he is hungry. But it is when the crab has to change his house that his care and attention are redoubled. He assists the anemone to move with all the address of which he is capable, and if the proposed new house does not suit him another is selected, that the Adamsia may be fully satisfied.

More than a hundred species of soldier crabs, scattered through all seas, are known, and all lead the same sort of life.

Another sort of companionship is noticed amongst crabs of the

genus *Dromia* (Squinado), which are of moderate size, and instead of lodging in a cell, dress themselves up from their early youth with a living colony of polyps, who grow with their growth. This colony has for its usual basis a live Alcyonium (Mermaid's Finger, or Cow pap), which covers the carapace and adapts itself as it develops to the inequalities of the cephalo-thorax, so that it seems an integral portion of the crab. Sertularia and Coryne grow in abundance upon the Alcyonium, mixed with sea-weeds, and the Squinado, masked by the living burden which he bears like Atlas on his shoulders, marches sedately to the capture of his prey. Concealed in the bush of a virgin forest, he has no fear of attracting the attention of an enemy. There are many mysteries to bring to light concerning the inoffensive population which the Squinado carries whenever he has blood to shed. These crabs are not rare in the Mediterranean, but they are seldom seen in the North Sea.*

Another crab, *Hypoconcha sabulosa,* whose carapace is too tender for him to go about naked, covers himself with the shell of a bivalve mussel.

Some Crustacea of the order Amphipoda lodge in a real crystal palace, choosing for their dwelling the transparent body of a Salpa, a Bervöe, or a Pyrosoma, and in the interior of this crystalline lodging, which is often alive, he devotes himself to the pleasures of fishing. The *Phronima sedentaria* usually occupies a Salpa. These Crustaceans have been met with in different seas; but one of the most remarkable examples was observed by Mrs. Toynbee (Lady Smyth) in lat. 3° 42′ S., long. 76° 19′ E., and from her beautiful drawing, which is reproduced in the superb atlas of Commodore Maury, it was a true *Phronima.* I may be permitted to record my admiration of Mrs. Toynbee's researches, by which she has enriched science, and of the splendid drawings she has brought home from her voyages.

We find often on our coasts the *Hyperia Latreilli* lodged in the great jelly-fish (*Rhizostoma*), which appears regularly in the autumn on the shores of Ostend.

The isopod Crustaceans include a division of animals regularly formed, and somewhat resembling wood-lice, which live on various fish—the Cymathoads—armed with strong hooks for attachment, but often, when the whim takes them, swim away from one fish and fasten on another. They are true fellow-boarders who like being

* They are common on our southern coasts, and are very amusing in an aquarium.—Ed.

carried by others better than using their own paddles. They are found in all seas, and Dr. Bleeker made us acquainted with many belonging to the Indian Ocean. On the coasts of Britain, where different species of Wrasse are common, it is rare to find one of these fish who does not lodge a couple of these Crustaceans.

Besides the barnacles who live as fellow-boarders on the whales, the latter give lodging on the surface of their skins to Crustaceans, who preserve their liberty, and quit one host to establish themselves on another. These are the whale lice (*Cyami*), who live upon the Cetaceæ as the previously-mentioned isopods live on fish. The members of the genus *Caprella* usually attach themselves either to whales, or turtles, or fish, or to Sertulariæ, and appear to live under the same conditions.

The Pcynogons, whose nature and mode of life have appeared problematical up to this time, deserve to be reckoned equally amongst the fellow-boarders, at least during their youth. They live, in fact, after they are hatched, on Coryne, Hydractinia, and other polyps; and it is only at a later period that they haunt mollusks and more elevated creatures.

The Mollusks of all the lower ranks show most independence, contenting themselves with the slowness of their progression and the poverty of their food, and seldom asking the aid of their neighbours.

The mode of life of the animals which have occupied our attention makes us understand the relations subsisting between certain Gasteropods and Echinoderms. The Gasteropods in question are known as belonging to the genus *Stylifer,* and they have been long noticed in star-fish, *Asterias, Ophiura, Comatula,* and even in sea-cucumbers (*Holothuriæ*); and as they were constantly found in the digestive cavity of these Radiates, they were supposed to be present as parasites. This opinion was first expressed by D'Orbigny, and adopted by most naturalists. They are, however, only parasites in appearance, and are really nothing more than fellow-boarders. These delicate Gasteropods have been successively ranked among the *Phasianellæ,* the *Turritellæ,* the *Cerithii,* the *Scalariæ,* and the *Rissoæ;* but Mr. Gwyn Jeffreys has just proposed, and with reason, to erect them into a distinct family. These Stylifers sometimes place themselves at the entrance of the mouth; but generally, like the Donzelle, they prefer to lodge deeper in the digestive cavity, in the midst of the food.

Quite recently, Mr. Stimpson has pointed out, in the Port of Charleston, a Gasteropod Mollusk, like a Planorbis (*Cochliolepsis para-*

situs), which lives as a fellow-boarder on the body of a worm, *Ocoetes lupina.* Some other Mollusks, such as *Madiolaria marmorata,* lodge as fellow-boarders in the mantle of an Ascidian, as the *Magili* establish themselves in the interior of Madrepores. We may also cite *Vermetus, Crepidulus,* and *Hipponyx,* which instal themselves in other shells, and only ask a corner for a lodging.

The class of worms not only comprises parasites, but possesses likewise, as we shall soon see, fellow-boarders also. We find them on Mollusks, on animals of their own class, on Echinoderms, and even on Polyps. One of the most curious worms is the Myzostome, which lives on the Comatula, the true nature of which has just been revealed by the labours of Mecnikow. These Myzostomes resemble Trematode worms, but they possess symmetrical appendages covered with vibratile cilia. They run about the Echinoderms with remarkable rapidity, and have not yet been found in other situations. They are no more parasites than the preceding, but take their place beside them as free fellow-boarders.

There are many worms which live as companions in the same sheath with their congeners, and even with included Mollusks. We may cite the *Lepidonotus cirratus,* and the *Chætopterus insignis,* as well as the *Lycoris fucata,* which inserts itself in the holes of the Teredo. M. F. Müller mentions an Amphinome which establishes itself in *Lepas anatifera.* There is also a larva of a Nemertian worm (*Alardus caudatus*), which lives in the digestive tube of a neighbour, and whose mode of life has been misunderstood. In opening the *Pylidium gyrans,* we often find in the interior of its digestive cavity a larva which was once thought to belong to it by affiliation; but the Alardus is only a fellow-boarder—at least in its young days, and at a later period can probably shift for itself.

We likewise find, commonly, a fellow-boarding Nemertian, the *Polia convoluta,* amongst the eggs and under the tail of the common crabs which belong to our coasts.

An elegant Gasteropod, the *Phylliroe bucephala,* carries a singular appendage on its head, which has been long noticed by naturalists, though its nature has only lately been understood. It is the *Mnestra parasites.* Müller first took it for a Medusa, but he afterwards abandoned that opinion, when Krohn definitively arranged it amongst the Polyps, only differing from its congeners by its form, its four ciliated tentacles, and its mode of life. Thus we have a polyp as a fellow-boarder.

A superb sponge, *Euplectella aspergillum,* from the Philippines is planted in the soil, and shelters three kinds of Crustaceæ, pea-crabs,

prawns, and isopods. The *Phelomedusa vogtii*, which lives on *Halecampa Fultoui*, also deserves mention.

We now come to the

FIXED FELLOW-BOARDERS.

The fellow-boarders of which we have been speaking preserve their full and entire independence at all periods of their lives, and as they only undergo ordinary changes in form, their true nature has rarely been misunderstood. By the side of these we see others who are only free during their young days, and when the epoch of puberty approaches they make choice of a host, throw off all their travelling appendages, including their eyes, change their clothes, and become completely dependant upon the animal that carries them. Others, again, only renounce their independence for a time, and preserve even during their sequestration their proper form and their organs of locomotion. The most interesting of the fixed fellow-boarders are evidently the barnacles *Tubicinella, Diadema, and Coronula,* which cover the skin of whales. They are like all the others, free during their infancy; but for motives of their own, they locate themselves on the head or the back of these great Cetaceans, which they never quit when once settled. That which is of especial importance to these companionships is that each whale lodges particular species, so that the fellow-boarding Crustacea are like a flag of nationality, and the equipment causes the ship to be recognized. The great northern whale *Mysticetus*, which our hardy and patient neighbours discovered on seeking a passage to India by the East, a species which never quits the ice, does not carry barnacles. It is this whale that was already known to Iceland fishermen of the twelfth century. These intrepid whalers distinguished between a northern whale without calcareous adhesions, and a southern whale with them. This last is the celebrated whale of the temperate regions, the "North-Kaper," which the Basques hunted from the tenth century in the Channel, and which at a later period they chased as far as Iceland.

We also find characteristic Cirripeds on the genus *Megoptera* on dolphins, on some of the sharks, and on tortoises, and their inferior ranks are met with on sponges, and in the tissues of many true Polyps. But if the greater part of these Crustaceans lose their proper physiognomy while possessing the appendages symmetrically disposed round the mouth, there are also some who get rid of all their external apparatus and become a mere sac of sexual organs, such as *Sacculina* and *Peltogaster*, who lead a miserable life in the abdomen of common crabs or on the backs of soldier crabs.

We also see Cirripeds establishing themselves on other Cirripeds, losing their appendages, and taking the form of the larva of a Diptera. The genera *Otion* and *Cineras*, which we find on the keels of ships, as well as on the bodies of fish, are fellow-boarders on other Cirripeds, but preserving their own form.

From the time of the ancients a fish was known, whose position was not well made out until our day, and which seems to belong to the category of fellow-boarders. It is the *Echineis*, or Remora, an animal found in the Mediterranean and other seas, attached to the bodies of large fish, especially sharks, by means of an apparatus for adhesion situated on its head. It has sometimes been confounded with the pilot fish. It is a fellow-boarder, but, contrary to those just mentioned, can free itself when it pleases, and seek a new host. It lives by its captures during the voyage. The Remora has always attracted the attention of observers. In the eyes of the ancients a singular being, no matter of what sort, must have some peculiar action upon the animal economy, and could not fail to enter into the composition of divers therapeutic preparations. Pliny pretends that the Remora served to compose poisons capable of extinguishing the fires of love.

The sailors now, as of old, are convinced that if one of these little fish adheres to a ship it arrests its course. That which is not doubtful is that the inhabitants of the coast of Mozambique turn to account the Remora's faculty of attaching itself to animals, for they put a ring in its tail, to which they attach a line, and let it go in the sea and stick to what prey it may find. Thus Remora-fishing is the counterpart of hawking.

Amongst the Polyzoa there is a curious genus living on Annelids, and concerning the nature of which we have been led into error. My fellow-labourer, M. Hesse, represented it as a Trematode with a stalked sucker situated behind, and we have given it the name of *Cyclatella*, which ought to be abandoned. The pretended Trematode is a true Polyzoon belonging to the genus *Loxosma*, and which lives as a fellow-boarder fixed on the Annelids.

There are likewise fellow-boarders, who in their early growth place themselves under the protection of a complaisant neighbour or a parent, and are then transported to their destination. These do not lose the character of their youth. Among them are the young of the Caligus; for, according to the observations of M. Hesse, of Brest, these Crustaceans, in order to reach the fish they are destined for, attach themselves to a parent or a friend by the aid of an appendix of the cephalo-thorax, and are rowed to their residence.

Forty years ago Jacobsön of Copenhagen wrote a memoir to demonstrate that the young bivalves which are found on the external branchiæ of Anodonts are parasites, for which he proposed the name *Glochidium*, and Blainville and Duméril were requested to report on this paper, which was sent to the French Academy. Their opinion gained few supporters, and it is now well known that the young Anodonts differ considerably from the adults, and that during their sojourn in the branchiæ they carry a long cable which descends from the middle of the foot. What is this cable for? Is it to attach the young Anodont to the body of some fish which will carry it to a distance? The Anodonts have not, like other Acephala, or headless mollusks, vibratile wheels to disperse themselves.

At the bottom of ponds and rivers there are Rotifers and Infusoria which attach themselves to Crustaceans and insects, and travel like the Cirripeds of the whales. There thus exist fellow-boarders of the two categories in the lower ranks of aquatic animals.

We shall finish by remarking that in all combinations between individuals of different sexes, as between those of different species, we always find the object attained, the conservation of the individual and the conservation of the species. These phenomena evidently depend on the secret ordinance of Providence, and the life of the humblest worm hangs from the same thread as that of the greatest mammal. A breath suffices for their creation and their annihilation. God holds the chains of all their existences, and conducts them to their end. It is for us to observe the facts, and to guess in generalizing them the laws by which they are regulated. And if we have need of an hypothesis to guide us through the dark places, do not let us assign to it the importance of a scientific conquest, for this hypothesis is only a beacon to guide us on our route.

We close here for the moment the observations to which we may revert some day. In conclusion, let us repeat the words we lately used under analogous circumstances and in this place—the grandeur of nations is measured to-day by the scale of their intelligence. Let us take our part in those learned researches which are assigned to us amongst European peoples, and encourage with all our power the study of the sciences and the cultivation of the arts, those two levers of civilization. In that let us place our glory. Instead of stifling the spirit of investigation in our superior schools and leading minds to expend their forces in sterile disputations, constitutional governments should, more than absolute monarchies, afford a good example, and without ceasing urge the nation to the glorious and fruitful conquests of science.

PROBABILITIES IN SCIENCE.

All science depends upon the probability of certain things being true, and certain inferences being correct. If an hypothesis explains a number of phenomena, which do not appear to be susceptible of so good an explanation, or of any explanation at all, by another supposition, we have a strong inducement for believing it to be correct. Up to a certain point of knowledge, astronomical facts and appearances were accounted for to the satisfaction of acute minds by the Ptolemaic system, and in like manner a certain quantity of fact relating to light was explicable upon the theory of an emission of luminous particles, radiating in straight lines. Both these theories had to give way before an increase in the number and kind of known phenomena, which had be accounted for, and which they proved incapable of including. Within limits, which are perhaps impossible to define, that theory is the most probable which explains the largest number of phenomena, but mere quantity of this sort of evidence does not always strengthen belief. For example, our belief that the sun will rise at the time calculated by astronomers to-morrow morning, is so strong as to be termed complete, and it will not be increased this time next year, because there will by that date have been a certain number of additional coincidences between the predictions and the results.

In many cases our minds are strongly influenced by the variety, as well as by the quantity, of the facts which a given theory coordinates in that particular manner to which we apply the term *explanation*. Thus, in the case of light, the capability of the undulatory theory to explain phenomena of polarization and diffraction, as well as those of reflexion and refraction, adds much to its credibility.

In like manner, the nebular hypothesis has grown in probability by a succession of discoveries and observations, which are found consistent with it; but there is at present so much that remains unaccounted for, that we may be justified in thinking that this theory will have to be modified, as well as completed, before it can reach the degree of probability attained by the undulatory theory of light. Mr. Proctor has, we know, some interesting speculations on this subject, which we hope he will work out.

In all speculations on the condition of highly attenuated matter, such as nebulæ, or comets, swimming in the cold and rare fluid

that occupies the regions of space, we are under great difficulties from want of analogies to help us. The matter of comets is in a condition, not like anything we are acquainted with in some important particulars. Sir John Herschel says, "it is evident that the most unsubstantial clouds which float in the highest regions of our atmosphere, and seen at sunset to be drenched in light, and to glow throughout their whole depth as if in actual ignition, without any shadow, or dark side, must be looked upon as dense and massive bodies compared with the filmy, and all but spiritual texture of a comet." In 1767, Lexell's comet approached Jupiter, by whose attraction its orbit was materially changed, but its mass was so small that it was not able to produce any noticeable disturbances in the little bodies of the great planet satellites.

Cometary matter does not appear to be in one state only. Sir J. Herschel says of them:—"In all probability they admit of great varieties of structure, and among them may very possibly be bodies of widely different physical constitution, and there is no doubt that one and the same comet, at different epochs, undergoes great changes, both in the disposition of its materials, and in their physical state." We do not know matter in the state in which comets must be when they shoot out their enormous tails with astounding rapidity, and to prodigious lengths. The comet of 1680 was found by Newton to have emitted a tail 20,000,000 leagues long in two days, and it went on increasing. The comet of 1843 was seen to shoot out a ray, or tail, to the extent of nearly 100° in a single day, and upon this Sir John Herschel remarks, "It is clear that if we have to deal here with matter, such as we conceive it, possessing inertia at all, it must be under the dominion of forces incomparably more energetic than gravitation, and quite of a different nature." Soon after passing its perihelion the tail of this comet increased thirty-five million of miles a day. The emission of cometary tails takes place in a direction opposite to the sun, and that body is presumed to exert a repulsive force upon the matter so made to travel with astounding rapidity. If we are to follow analogy and recognise all the forces acting upon matter as modes of motion of the particles thereof, we shall be led to suspect that cometary matter is in a condition to be impressed with motions different from those we know more or less about, as they are exhibited in heat, electricity, and so forth. It is obvious, therefore, that when the spectroscope is applied to a comet, though it is highly probable that Mr. Huggins is right in the conclusions at which he has arrived, we do not really *know* how to compute the probability

of his interpretation of its indications being correct. This is perhaps still more the case in the spectroscopic investigation of nebulæ. An indication of incandescent hydrogen, for example, obtained by such means, is not quite conclusive, and it is, in the present state of knowledge, impossible to ascertain exactly what it is worth.

An experimenter wishing to obtain a spectrum of incandescent hydrogen, operates with a coil machine and a Geissler tube. He makes the rarified gas luminous by a powerful electric discharge, which strongly heats it, and in comparing his results with those obtained with the light from a nebula two suggestions occur. First, we have no evidence that the luminous nebula is intensely *heated*, by any internal action, or by any external force. In the next place we know scarcely anything about the density of the matter that composes it. At first it would seem that if highly heated hydrogen gave a particular spectrum in the laboratory experiment, it was highly improbable that exactly the same spectrum should appear, except similarly heated hydrogen were its cause. The amount of improbability of *accidental* coincidence is enormously great—great enough to be discarded. From a moderately extensive range of experiments, we know that a considerable number of the bodies, which we call "simple," simply because we cannot, or have not decomposed them, afford, in the state of incandescent vapour, characteristic spectra, and from this it is inferred that this rule holds good under all circumstances. Certain facts in the spectra of gases raise some doubts,* but it must be admitted that a powerful probability is established that certain nebulæ are composed of luminous, if not of incandescent† gaseous matter, to which the term incandescent is commonly applied, though before we know how to estimate the value of this probability we must see what other probabilities are raised by the same or other researches.

On making his most important examination of a nebula in Draco, Mr. Huggins saw three isolated bright lines, instead of the continuous spectra given by stars, and he said, "a spectrum of this character, so far as our knowledge at present extends, can be pro-

* "An apparent exception to the law that the nature of the spectrum of a gas remains constant throughout a great temperature range, ought to be remarked in the case of nitrogen, which changes the nature of its spectrum at a very high temperature. This is viewed by some as an indication that nitrogen is really a compound body, since the same change takes place in the spectra of some other gases, which we know to be compound."—Balfour Stewart, "An Elementary Treatise on Heat." Plücker has made important observations on this subject.

† Incandescent properly means being made white by heat.

duced only by light which has emanated from matter in the state of gas. The light of this nebula, therefore, was not emitted from incandescent solid, or liquid matter, as is the light of the sun and stars, but from glowing or luminous gas."

On comparing the spectrum of nitrogen with that of the nebulæ, Mr. Huggins says, "I found that the brightest of the lines of the nebulæ *coincided* with the strongest of the lines that are peculiar to nitrogen. It may be, therefore, that the occurrence of this one line only, indicates a form of matter more elementary than nitrogen, and which our analysis has not yet enabled us to detect. In a similar manner the faintest of the lines was found to coincide with the green line of hydrogen." He adds, "the middle of the three lines which form the spectrum of the nebula does not coincide with a very strong line in the spectra of about twenty of the terrestrial elements. It is not far from the line of barium, but does not coincide with it." A minute nucleus of this nebula appeared to be the source from whence a faint continuous spectrum was obtained, and thence it was inferred to consist of opaque matter, which may exist in the form of an incandescent fog of solid or liquid particles." The comet of 1866 afforded a continuous spectrum from its coma, indicating that it was visible by reflecting solar light; but the nucleus was self luminous, and gave a gaseous spectrum, "suggesting that the material of the comet was similar to the matter of which gaseous nebulæ consist."

It is difficult to suppose that such thin bodies as comets and nebulæ can keep themselves very warm in the intense cold of space. From Professor Tyndall's researches, it appears that oxygen, nitrogen, air (which is a *mixture* of them), and hydrogen possess very feeble powers both of radiation and absorption. A heated mass of these gases would cool slowly from radiation, but a cold mass would be very difficult to warm by absorption of heat radiated from any other body. To retain nebulæ or comets in a state of incandescence from *heat* would require conditions that we do not know to exist. No one, we suppose, would imagine that heat, radiated from any other bodies, could keep a nebula white hot, and matter in so rarified a state is not under favourable circumstances for violent chemical actions, such as we know produce great elevation of temperature. We may, however, have recourse to that refuge for those destitute of accurate information—electricity—and assume that the nebulous glow which acts upon our spectroscopes comes from electric excitation. But if this be so, we have gaseous matter not *heated* to incandescence giving the same

spectrum as gaseous matter that is so heated in our laboratory experiments; and, before we can tell the probabilities of the inferences usually drawn from the spectra of comets and nebulæ, we must ascertain that the same gaseous matter in these two conditions would give the same spectroscopic results. Any probabilities that nebulous matters are not incandescent from heat are probabilities that the laws of luminous spectra are not so simple as to be comprised in the statements we usually receive, and according to which we are invited to believe that the same form of matter in the same condition gives a spectrum belonging exclusively to that matter in that particular state.

When we consider comets, how are we to be guided in guessing their temperature? The comet of 1843 went so near the sun as to be exposed to 47,000 such suns' heat as we experience the warmth of, and Sir J. Herschel, from whom we take this statement, observes that the heat emitted by the sun in such a position would be equal to three and a half times that obtained with Parker's great lens, thirty-two and a half inches in diameter, when used with a concentrating lens, increasing its power sevenfold, and melting carnelian, agate, and rock crystal with the solar rays. The actual temperature of the matter exposed to this solar glare and glow would depend upon its nature. If very transparent to heat, it would let much through and retain little. If the heat excited other actions, such as great expansion, or other internal work, all so employed, would not raise its temperature. Many comets seem to grow smaller as they approach the sun, and this has been supposed to arise from portions being converted into a more attenuated and invisible condition. As they recede from the sun they have been observed to get visibly bigger—probably from condensation. If cometary or nebulous gas passes from a condition the same as or like what we call simple gases, to that of compound gases, its powers of absorption and radiation would, according to Tyndall's researches, be enormously increased.

Professor Tyndall, in his "Heat as a Mode of Motion," affirms that the chances that iron is in the sun are 1,000,000,000,000,000,000 to 1, on account of the coincidence of certain dark lines in its spectrum with certain bright lines yielded when incandescent vapour of iron is employed as the source of light. This is put forth as an *actual* calculation. It may be *actual* in the sense that Professor Tyndall actually made it, but purely imaginary at the same time. The elements for a *real* calculation of the probabilities are not known. Very likely the professor is right if he

thinks only of coincidence arising from *chance*, but we have no information whatever concerning the probability that coincidences may result from *law*. The quantity of experiments yet made is insufficient to justify such extravagant assertions, and no one has yet arrived at a law explaining why the spectra of different so-called simple bodies vary exactly as is found to be the case. No philosopher really imagines that there are scores of substances which are really simple, and if, as is probable, the chemist may find means of decomposing metals, and certain gases, or carbon, who can venture to predict what fresh spectra may appear.

Our purpose is by no means to argue against a balance of probability that the present interpretations of spectroscopic phenomena are correct, but to point out what we must ascertain and take into account before the real probability of their correctness can be estimated.

Let us now glance at certain points in Laplace's famous nebular theory as affected by probabilities. As we have already stated, Mr. Proctor has turned his attention to the subject, and we shall not touch upon or anticipate matters which we believe he has under consideration, and which will propably eventuate in new views. M. C. Delaunay, in his "Cours d'Astronomie," gives a very succinct and intelligible account of Laplace's theory, which begins with one great nebula, containing all the matter to be formed into our sun and his system. The great nebula revolves upon an axis; and here we ask whether any nebula is known to do anything of the kind? If not, how was the motion likely to arise? A progressive cooling of the nebulous mass is the next portion of the theory, but how do we know that nebulæ are hot? If the supposed nebula consisted of intensely-heated gaseous matter, it would contract in cooling, and the cooling would take place by radiation of its heat into space. But if this be granted as the process of world-formation, account must be taken of the effect of condensation in bringing chemical, electrical, and molecular forces into play. As soon as certain elements were brought near enough, there would be a great rushing together of their atoms, and the condensation would not follow the rule of heat, and operate most rapidly in the outer layers nearest the cold of space, but would be quickest near the centre, where the chemical affinities would act more powerfully. Laplace's theory supposes that the nebula, in contracting as it cooled, accelerated its velocity, and threw off successive rings, because the force of gravity, acting from the centre, could not keep the whole mass together against the strong pull of centrifugal power arising from the rapid and quickening rotation.

Without knowing how much and how quickly chemical forces would influence the condensation near the central and densest portion of the cooling mass of vapours, we cannot tell how far this regular process of ring formation would be interfered with. It is clear it would not go on as if the gradual withdrawal of heat by radiation were the only cause of change. If a great bulk of gaseous matter contracted suddenly by chemical action into a molten mass of mineral matter, enormous heat would be given out, and this would affect the more attenuated matter immediately beyond, while that still further off would come rushing down in great storms to fill the void suddenly produced.

Helmholtz, cited by Tyndall, estimates the heat occasioned by nebular condensation as prodigious in intensity. Tyndall, describing his opinions, says, that supposing the nebulous matter to be in the first instance of extreme tenuity, and the specific heat of the condensing mass the same as that of water, then the heat of condensation would be sufficient to raise the temperature 28,000,000° centigrade, or about 13,000 times the heat of the Drummond light. A question arises whether condensation would take place under such circumstances, or at such a temperature, which we should be inclined to suppose would dissociate all chemical compounds. Nebular condensation, producing suns and planets, must give rise to chemical unions, and if heat were not the cause of the dispersion of the molecules of the nebula into the highly-attenuated form of those bodies, their condensation may not evolve heat as Helmholtz supposed.

If we conceive the original nebulous mass to consist of some ultimate element, out of which all solar and planetary substances were to be made, we must imagine that as soon as chemical actions began, and what we call "simple bodies" were formed, there would be considerable differences in their specific gravities, and the heaviest would settle down, so that the outer rings, which might be thrown off, would contain lighter matter than the inner ones. How far all these things are probable, and how far they would consist with the theory, must be considered before the probability of the theory itself can be estimated. A great convergence of reasons led to the belief that the solar system had a common origin from nebulous matter, but as yet no theory has sufficed to comprehend all the particulars that have to be accounted for.

We drop the subject of scientific probability at this point for the present, in the hope of considering some other time the real amount of evidence for many things that are commonly believed in other departments.

SPOTS AND MARKINGS ON THE LUNAR CRATER PLATO.

LUNAR ACTIVITY.

BY W. R. BIRT, F.R.A.S.

(*With a Tinted Plate.*)

AMONGST the records of observations of the moon's surface during the last 80 years, we meet with notices of phenomena apparently inexplicable on the principle of variation, either in the visual angle at which light is reflected from the moon to us, or in the illuminating angle, or that in which the sun's light falls upon lunar objects. We believe it was Schröter who first pointed out instances of this kind, if we except the elder Herschel, who remarked certain luminous appearances on the dark side of the moon, which he attributed to the eruptions of active volcanoes. The records of Schröter, bearing on this subject, are very numerous; but are more or less unsatisfactory, on account of the absence of referring them, by a proper mode of discussion, to such agencies as are above alluded to, and which we know are fruitful sources of producing apparent change. Most, if not all, of Schröter's instances have been questioned; indeed, it has been said that all were "illusions," and at the present period of lunar research the works of the first selenographer, who thought it worth his while to examine the surface of the moon in detail, are little thought of. Gruithuisen and Lohrmann followed, and we also find notices in astronomical works, about the period in which they wrote, of others. Gruithuisen certainly had a good eye, and if he had eschewed theorizing, his works would doubtless have been in greater request than they are at present. Lohrmann's map is one that can be consulted with great advantage, and those portions of his sections which have been published, are a great help to the student, who seeks to know the then state of any particular portion, records of which are preserved in the sections, presuming that he faithfully recorded what he saw. The great work in Selenography, as every one knows, is the large map of Beer and Mädler, and the accompanying letter-press "Der Mond." This has been considered as so complete that very little is left to add to it, yet we find that another map of about twice the size has recently been completed by Schmidt of Athens, and of late years a considerable impulse has been given to the study of Selenography, with great promise of making still further advances in it.

If any one will take the trouble to *compare* the existing selenographical records which we possess, more especially as regards the smaller objects, he will soon be startled by detecting differences between them, and as the best way of settling these differences he

refers to the great original, and finds it very difficult to reconcile them, either with each other or the moon—for he soon discovers that the appearance of any given object alters from night to night, and it is not long before he refers most of the altered appearances, which he witnesses, to the different directions in which the sun's light falls upon it. He also notices that the forms of objects vary quite independently of the direction of the incident light, and that this alteration in the form of an object is connected with its approach to, or recess from, the nearest edge or limb of the moon, and in consequence he is disposed to regard all such alterations as merely apparent. It is, however, manifest, that in order to be certain that alterations in the appearance and form of an object *are only apparent*, correct records of them should be preserved, accompanied with the time (Greenwich mean time is best) at which they were noticed, the position of the moon (latitude and anomaly), the distance of the sun from the moon's ascending node, which gives the season at the moon, and the elements for computing the sun's altitude and azimuth at the object for the time of observation. A discussion of a long series of observations of any one spot, with reference to these elements, could not fail of showing if *all* the altered appearances were referable to alterations in the angles above-mentioned.

Schröter, as before remarked, has accumulated in his "Selenotopograpische Fragmente" a large number of observations of the kind above alluded to, and although he did not discuss them in reference to illuminating and visual angles, yet he regarded them as indicating the operation of agencies more or less connected with the moon, such as volcanic or atmospheric, for he speaks of *new* craters, and refers on many occasions to phenomena, which to him appeared to result from an atmosphere preventing, for example, the inspection of the depths of well-known craters and other objects. I should hardly have referred to these instances of Schröter, had not phenomena of the same kind presented themselves of late years. In the "Supplemental Monthly Notice of the Royal Astronomical Society," Vol. xxiv., for the years 1863-1864, is a paper by the Rev. T. W. Webb, on certain suspected changes in the lunar surface. After directing the attention of his readers to these supposed changes, and disposing of the question as to their being affected by libration, he says, "It remains that they must be accounted for as far as I can see, either by the supposition of inadvertency on the part of former selenographers—of actual physical alteration of surface—or of some kind of obscuration arising from eruptive action, or from the changed

conditions of a possible lunar atmosphere—an alternative due to Schröter who frequently had recourse to it in order to explain appearances, of which it seemed to him that no equally reasonable account could be given." In the course of my own observations I have met with many instances similar to those given by Schröter and Webb, and, indeed, my late experience is such that I am very strongly disposed to withdraw altogether Mr. Webb's first alternative and exonerate my predecessors from the charge of "inadvertency," as from the late observations of the floor of Plato, to which I shall presently allude, I am satisfied that many of the supposed omissions of Lohrmann, Beer and Mädler, and others, really arose from the omitted objects not having been visible at the time they were observing.

The strongest instance of supposed change on the surface of the moon, is that of Linné. This has not been substantiated, for we cannot consider that a mooted point is settled, unless the most incontrovertible and irrefragable *proof* be offered. The assertion that the state of Linné, at present, does not agree with that represented by the drawings of Lohrmann, Beer and Mädler, and Schmidt, each having been made at different and somewhat widely separated epochs, and neither of them confirmed by contemporaneous observations, may be regarded as inconclusive as that of there having been no change; each is destitute of the necessary proof to establish it, for of the drawings it has been said, "they are merely conventional"; and although it is true that Lohrmann describes Linné "as a very deep crater," which it is certainly not at present of the size represented by him, yet it seems that the evidence drawn from this statement is so weak, as not at all to weigh against the opposite conclusion of "no change"; and this lacks in a similar, or even greater degree, its proof, for no steps have as yet been taken, so far as I am aware, to discuss the observations of Linné, which we now possess, in reference to the elements of visual and illuminating angles, in order to ascertain if, since the observation of Schmidt on the 16th October, 1866, Linné has remained in precisely the same condition, and that the white cloudy spot *always* appears when the sun attains the *same* altitude as he ascends above the horizon, and disappears *always* at the *same* altitude as he descends towards it.

More than two years ago, Herr Tempel called attention to the small white spots so numerously seen on the moon's surface, especially about the time of full, and intimated that they might be the result of a chemically warm activity. To test this suggestion

is a matter of no little difficulty. If the spots be due to action now going on, how can we get at it? The only way appears to be, to ascertain if under similar conditions of illumination and libration they are always visible. They are so very numerous, that to examine this question a selection of a few is absolutely necessary, but even if this be done, we need in the first instance powerful telescopes, in the second active and persevering observers, in the third many such observers, and in the fourth a present and constant discussion of the observations made, in order to determine which of the spots selected have been visible during a certain period, and which invisible. My acquaintance with the floor and surroundings of Plato, prompted me at once, on receiving a drawing of *eleven* spots, seen by Mr. Pratt of Brighton, on the evening of Feb. 23, 1869, to endeavour to organize a course of observation for the object of testing Herr Tempel's suggestion, and Mr. Edward Crossley of Halifax, entered very warmly into the subject, and requested his assistant, Mr. Joseph Gledhill, sedulously to observe the spots and markings on the floor of Plato, with his 9·3 achromatic, by Cooke. Both Mr. Gledhill and Mr. Pratt, with his eight inch silvered glass reflector, have continued their observations to the present time, and other gentlemen have also assisted. I have received the observations regularly, and as regularly have discussed them, and succeeded in obtaining the following results.

First.—The number of spots which have been actually seen on the floor of Plato is 32, of these a few are very small craters.

Second.—The number of separate light-markings on the floor is 20.

Third.—Both spots and markings are exceedingly variable in their *visibility*. Small portions of the markings and but few spots being visible at any given moment.

Fourth.—Regarding the central spot on the floor as the standard, and assigning to it the numerical value of 1·000, it is easy to determine in reference to the central spot the degree of visibility of each of the others: 417 observations between Feb. 22 and Nov. 27, 1869, have been employed for this purpose.

Fifth.—On dividing the 417 observations into two groups, viz: 246 from Feb. 22 to Sept. 27 inclusive, and 230 from August 16 to Nov. 26 inclusive, 59 being common to each, and determining for each group the degree of visibility of each spot, we find, as given in the following table, a great irregularity in the increase and decrease of visibility in the latter, as compared with the former period; but on plotting down the signs of the differences,

we find an arrangement which indicates at least some regularity in the distribution of increase and decrease, thus the spots which have manifested an increase of visibility, are found on the central part of the floor stretching from west to east. In the large group of increased visibility, only one spot, No. 10, is found that has decreased; the remaining eight spots that have decreased are found, three in the S.W. quadrant of Plato and five near the north border.

SPOTS ON PLATO.

No.	Discovered by	Visibility Feb. to Sep. 246.	Aug. to Nov. 230.		
0	Gruithuisen		·071		
1	Gruithuisen	1·000	1·000		Central easy, generally of the same appearance.
2	Gruithuisen	·030	·036	+·006	Seen twice by Gledhill and thrice by Pratt.
3	Gruithuisen	·727	·929	+·202	Dawes's double crater, frequently seen single.
4	Gruithuisen	·848	·893	+·045	Departs often from typical state, seen double by Pratt
5	Challis	·636	·500	—·136	Not seen so frequently as 3.
6	Gruithuisen	·242	·500	+·258	Seen by Pratt, Gledhill, Elger, and Cook.
7	Gruithuisen	·273	·250	—·023	Seen by Gledhill, Pratt and Elger.
8	Gruithuisen		·036		Seen by Pratt and probably by Gledhill.
9	Dobie	·151	·286	+·135	Seen by Dawes, and lately by Gledhill and Pratt.
10	Pratt	·212	·107	—·105	Seen by Gledhill and Elger.
11	Dawes	·030	·143	+·110	Seen only by Gledhill on twelve occasions.
12	Gledhill	·091	·071	—·020	Seen only by Gledhill on four occasions.
13	Plummer	·515	·286	—·229	On curved streak in N.W. frequently seen.
14	Pratt	·636	·536	—·100	On central arm of "Trident," frequently seen.
15	Dawes	·030	·071	+·041	Seen only by Gledhill on two occasions.
16	Pratt	·394	·286	—·108	On curved streak in N.W., occasionally seen.
17	Mädler	·666	·857	+·191	On west edge of sector, frequently seen.
18	Gledhill	·030	·143	+·113	Seen only by Gledhill on six occasions.
19	Gledhill	·515	·250	—·265	On curved streak in N.W., frequently seen.
20	Knott	·091	·071	—·020	Near north border, seen by Pratt and Gledhill.
21	Knott		·071		Near north border, seen by Pratt and Gledhill.
22	Mädler	·303	·464	+·161	Seen lately by Gledhill, Pratt, Elger, and Cook.
23	Pratt	·030	·036	+·006	Seen once by Pratt, and thrice by Gledhill.
24	Elger		·071		Discovered by Elger, 1866, Nov. 20, and seen five times by him since.
25	Elger		·107		Discovered by Elger, 1869, Oct. 18, and seen five times by him since, also twice by Pratt and once by Gledhill.
26	Gledhill		·036		Discovered 1869, Oct. 25, at foot of S.E. border base of sector.
27	Gledhill		·036		Discovered 1869, Oct. 25, at foot of S.E. border base of sector
28	Gledhill		·036		Discovered 1869. Oct. 25, at foot of S.E. border base of sector.
29	Pratt		·036		Discovered 1869, Nov. 15, seen since by Gledhill.

The fact of but few spots having been seen at any given moment is very suggestive, and seems to indicate that if the spots be due to present action, it is intermittent, the spots being visible only at

the time when it is in operation. The observations are at present far too few on which to found anything in the least degree approximating to a theory, especially as so many sources of difficulty exist in arriving at a satisfactory conclusion. Even if the effects of the earth's atmosphere were eliminated, personality enters so largely, that it will require a very long series of observations by several observers to get rid of its effects; nevertheless, the principle adopted is calculated to eliminate both. A remarkable instance of the effects of the earth's atmosphere, occurred on the evening of the 15th Nov., 1869. Mr. Gledhill at Halifax, who mostly sees the larger number of spots, recorded on that evening, 8 to 9 G.M.T., only 4. Mr. Pratt at Brighton, from 9.45 to 10.30 recorded 18. The difference in this case can only be referred to the different states of the earth's atmosphere at the two stations. When, however, we find—during two consecutive periods, one of eight months, the other of three months—246 and 230 observations by various observers respectively, contributing to the results—the increase and decrease of visibility arranged somewhat symmetrically on the floor of Plato, we are disposed to hesitate in referring all the differences of visibility to the effects of the earth's atmosphere. Nevertheless, one point has been gained, a knowledge of the intermittent visibility of the spots, as they are not all simultaneously visible, even with good states of the earth's atmosphere, and the great probability of their permanency. The following table contains a record of the markings on Plato hitherto observed.

Light Markings on Plato.

a Trident, very rarely seen complete.

b Sector, almost always visible, Gledhill and Elger give it fan-shaped from spot No. 4.

d Stem of Trident, not often seen.

ζ S.E. arm of Trident, brightest near the border, frequently visible.

ϵ Central arm of Trident, brightest near border, frequently visible.

e N.W. arm of Trident, seen at times bifurcated.

θ S.E. bifurcation of N.W. arm of Trident.

δ N. bifurcation of N.W. arm of Trident.

f Short streak on W. part of floor, seen by Elger in 1866.

g Long streak on W. part of floor, seen by Birt in 1863.

h Short streak on N.W. part of floor, in a line with *f*, seen by Elger in 1866.

ε Curved streak on N.W. part of floor, W. of spot No. 16.

a Straight streak through or near spot No. 16.

i Webb's light elbow adjoining N.W. border, rarely seen of late.

κ Curved streak on N.W. part of floor, E. of spot No. 16.

β Streak from 3 to N.E. border, nearly parallel with *a*.

η Streak from 4 to E. border, nearly parallel with *β*.

γ Streak from 6 to E. border, nearly parallel with *η*.

l Branch from Sector to E. border, seen by Pratt.

n Streak across the floor, from N.N.E. to S.S.W., through spot No. 1, seen by Birt in 1863.

The Greek letters are Mr. Gledhill's designations, he being the authority for the streaks except *ε* and *ζ*, which have been observed previously; the italics are mine.

Mr. Elger's drawings (Oct. to Nov., 1866), bear great testimony to the hypothesis of the markings being *permanent*. All the streaks which Mr. Elger observed in that year have been re-observed in 1869 by Mr. Gledhill, I am able to make out 20 distinct markings as seen by Mr. Webb, Mr. Baxendell, Dr. Dobie, Mr. Elger, Mr. Pratt, Mr. Gledhill, and myself. These markings are very variable in their visibility. There is one peculiarity which is somewhat striking, they appear to be brightest nearest the border.

ON POISONS.

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No. II.

Living, as we do, in an age when scientific discoveries have rendered the detection of certain poisons comparatively easy, we have no fear of systematic poisoning, as it was at one time carried on in Europe. The idea of a person dying slowly from a poison intentionally administered but rarely enters the mind, and but few cases of slow poisoning have occurred in this century. There is something positively fiendish in the disposition which can bear to be the cause of the terrible suffering produced by the continued administration of small doses of an irritant poison. One would think that the anxious looks, indicative of more than bodily pain, the excruciating agony, the delirious excitement, the blood-shot eyes, the nervous twitching of the body of the sufferer would appeal, and not in vain, to the poisoner for mercy. But to such depths of brutality can human beings fall, that history tells us of one who caused the death of not less than six hundred persons by a poison which owed its effects mainly to arsenic. A woman named Toffania, at Naples, in the seventeenth century, sold a poison which was called Aqua della Toffania, also Acquetta de Napoli. Six or eight drops of this poison were sufficient to destroy life. She was discovered and imprisoned in 1709. Confession of her crimes was extorted by the rack. She was afterwards strangled. The best authorities assert that this acquetta contained arsenic. The effects produced by this poison, which was tasteless and clear as water, are given by Dr. Christison. "A certain indescribable change is felt over the whole body, which leads the person to complain to his physician. The physician examines and reflects, but finds no symptoms, either external or internal—no constipation, no vomiting, no inflammation, no fever. In short, he can advise only patience, strict regimen, and laxatives. The malady, however, creeps on, and the physician is again sent for. Still he cannot detect any symptom of note. He infers that there is some stagnation or corrupting of the humours, and again advises laxatives. Meanwhile the poison takes firmer hold of the system; languor, weariness, and loathing of food continue; the

nobler organs gradually become torpid, and the lungs in particular at length begin to suffer. In a word, the malady is from the first incurable; the unhappy victim pines away insensibly, even in the hands of the physician; and thus is he brought to a miserable end through months or years, according to his enemy's desire." In the description given by Hahneman of the effects of this poison, the sufferings are stated to be most intense. In a later case, in which Dr. Christison was consulted by the Crown, where death was produced by *slow* poisoning by arsenic, the symptoms were of a character too painful to be recorded here. The symptoms of *acute* poisoning by arsenic have already been described in the first article on poisons.* In slow poisoning they differ in some respects, the effect of the poison on the nervous system is more marked; there is frequently paralysis of the limbs, partial or entire. It sometimes begins in the hands, and then extends to the arm. Sometimes epileptoid seizures occur, and sometimes there are spasms, such as occur in tetanus (lock-jaw). Even after recovery, the paralytic state frequently continues for some time. A case is related by Amatus Lusitanus in which mania occurred, the person became so mad as to burst his fetters, and jump out of the window of his apartment.

It has already been stated that arsenic is used in the manufacture of candles. Some years ago, some experiments were made by Mr. Everitt on German candles. A great many examples of the so-called German wax or stearine composition candles were examined, and found to contain arsenious acid in varying quantities, from as much as ten grains to eighteen grains in the pound. Mr. Everitt also made experiments to determine in what form the arsenic leaves the candle during burning. He passed the products of combustion into a glass bulb, and through a tube eighteen inches long and one inch wide, which was kept cool. A quantity of water was condensed in the tube, which was found to contain arsenious acid. A small quantity of a white sublimate was collected in that part of the tube immediately over the candle, which was proved to be arsenious acid. It was also discovered that the arsenic was used in the form of arsenious acid, for when different parts of a candle were analysed, it was found that the upper part contained more of this substance than the lower; and this would be accounted for by the fact, that candles are allowed to cool with their tops downwards, so that, while cooling, the arsenious acid would by its weight, for it

* Page 8.

is heavy, sink down to the lower part of the candle-mould. From this irregularity of the mixture in one candle, it may fairly be concluded that there might be an irregularity in the composition of the mixture of which the candles are made, and thus a large quantity of arsenic might be collected in any one particular candle, and so, very dangerous consequences might ensue. We shall have again to revert to arsenic, when the method of separating poisons from organic mixtures is explained.

Next to arsenic, the chemist usually considers antimony, from the analogies which exist between them; but the toxicologist, regarding poisons from their action on the body, places mercury next in succession. The salt of mercury, which most commonly produces poisonous effects, is called corrosive sublimate—it destroys the membranes with which it comes in contact, corroding them rapidly. When applied to the skin of the body in strong solution, it destroys it, and causes it to peel off. This substance is eminently a corrosive poison, no sooner has it been swallowed, than its effects are felt, even before it has passed into the stomach, its peculiar metallic (styptic) taste being easily recognized. The vapour of corrosive sublimate is exceedingly irritating to the mucous surfaces, and after it has been once smelt, it is not easy to forget its odour. Corrosive sublimate (bichloride of mercury), or as it is called by chemists, mercuric chloride, is a white crystalline substance, it is heavy, and so great is its weight, that it serves to distinguish it from other crystalline substances used in medicine. It is formed by the direct union of mercury and chlorine gas, and the relative proportions in which these elements unite to form it, are 200 parts of mercury, by weight, to 71 of chlorine. It is usually made by heating mercuric sulphate with common salt; 296 parts, by weight, of the former, with 117 parts of the latter. Sodic sulphate is formed, and mercuric chloride passes over in the state of vapour, and is condensed. Corrosive sublimate is very soluble in water, but more so in ether. When a solution of it in water is shaken up with ether, the ether takes the corrosive sublimate from the water, and being lighter than water, it floats on its surface. This property is made useful, as will be afterwards seen, in the description of the analysis for mercury. Common salt assists its solution in water, and this is also a matter of importance, as salt being used as an article of food, is often present in considerable quantities in the stomach. It is more soluble in alcohol than in water, and in boiling than in cold water. It is usually seen in the form of a white powder, often containing fragments of crystals. If this powder be gently heated in a

reduction tube, it wholly volatilises, and again deposits on the cool part of the tube. The crystalline forms which it assumes are very beautiful. If the reduction tube be very small, about one inch long and a quarter of an inch wide, it is easy to sublime it, and collect it on a glass slide for microscopical observation.

The crystals are needle-shaped, intermixed with beautiful stellate forms. It will be necessary to recur to these various crystalline forms when treating of the analysis for mercury. Corrosive sublimate is used in medicine, but in very small doses, in scaly diseases of the skin, and as an alterative in certain chronic diseases. It is also applied externally in the forms of lotions and gargles, to diseased mucous surfaces, and sometimes in ointments in chronic skin diseases. When taken in poisonous doses, it acts as a very powerful irritant, causing a burning pain in the epigastrium (the region over the stomach), vomiting and purging. These symptoms come on almost as soon as the poison has been swallowed; the throat appears to be stopped up, or constricted; the styptic taste before alluded to, is at once perceived, and resembles the sensation produced by sucking a penny. The throat becomes tender, and pain is increased by pressure. The rapidity with which the throat symptoms come on is so great, that persons have been warned in time, while in the act of swallowing, and have ceased to drink the fatal poison. With corrosive sublimate, the throat symptoms are much more marked than in arsenic poisoning, that is, if the solution be not too largely diluted. Occasionally death has occurred without the poison passing into the stomach. A young woman who tried to swallow two drachms of corrosive sublimate, in the solid state, was unable to force it down on account of the constriction of the gullet. She died in six days, of mortification of the throat.* The stomach symptoms are usually very decided, the pain which is felt is increased by pressure, but in some cases it is absent. The matters brought from the stomach by vomiting are usually viscid and stringy, and contain, often, large quantities of blood. In this respect there is some difference from the effects produced by arsenic—corrosive sublimate, acting more as a corrosive and local irritant, causes greater discharges of blood. The countenance varies under the action of these two poisons; by arsenic it is sometimes caused to have a ghastly and contracted appearance, but with corrosive sublimate it is swollen and flushed; in this respect, however, there are differences in different cases, for some have a pale and anxious look.

* Case related by Dr. J. Johnstone, recorded by Dr. Christison.

The pulse is always quick, sometimes it is full; in others it is small, as it varies with the condition of the patient, for he may be either in a state of fever or of collapse.

Death usually occurs by syncope, *i.e.*, in a fit of fainting: it may be preceded by convulsions, or may take place in a fit of them. Diarrhœa is generally very profuse; but other excretions are generally suppressed. Corrosive sublimate seems to affect the nervous system more than arsenic during the inflammatory stage; the tendency to drowsiness is greater, tremors and twitchings of the extremities are more marked and frequent. There is more stupor, sometimes absolute coma, and sometimes paralysis of the lower half of the body.

The quantity of corrosive sublimate necessary to cause death is not easily ascertained. A child has been killed by three grains, and recovery has taken place after as much as half an ounce has been swallowed. The time in which the poison causes death is also very uncertain; it varies from two hours and a half to eleven days. It must be remembered that corrosive sublimate is much more soluble than arsenious acid, that its effects manifest themselves earlier, and that from its solubility it may be more easily got out of the body. Arsenious acid has been found adhering to the coats of the stomach after several days, and even encysted by the mucous secretion of the stomach.

Again, soluble mercury salts form compounds with certain organic substances which they meet with in the stomach, and these compounds are not dissolved, and therefore remain harmless until they are got rid of. For these reasons large doses may be taken whose effects may be modified, and so it is hardly fair to say that such a quantity as half an ounce can be taken without fatal results. A strong girl swallowed, soon after supper, a drachm of corrosive sublimate, dissolved in beer. In a few minutes she was found on her knees in great torture. All the primary symptoms of this kind of poisoning were present in their most violent form: burning in the stomach, extending towards the throat and mouth, followed in a short time by vomiting of mucous, and then of bilious and bloody matters. The usual phenomena attending the excretions were observed. The pulse was small and contracted, the countenance anxious, and stupor considerable, which was interrupted by fits of increased pain. Subsequently the pain in the stomach became much easier, but that in the throat worse. At length, in the course of the second day, a profuse discharge of saliva took place, the gums became spongy and tender, and the patient died on

the fourth day.* In this case no doubt the food taken modified the action of the poison on the stomach, and death seems to have resulted from salivation, which is usually considered to be a secondary effect of mercurial poisoning. As to the time in which death may occur, Dr. Taylor relates the case of a man aged thirty, who was found dead. He had vomited some half-digested food. Near him was a drinking-horn containing about three drachms of corrosive sublimate. It was ascertained at the inquest that he had died from the effects of this poison. The man was last seen alive at half-past eleven the preceding evening, and was found dead at seven in the morning. His extremities were cold, and it was inferred that he could not have been dead less than six hours. This would make the duration of life only two hours after taking the poison.

Mercurial salts, when taken in large doses, or in small continuous doses, generally produce what is called salivation, the teeth become loose, the gums spongy and tender, the breath fœted (having an odour peculiar to this affection), and the saliva flows freely. All persons are not liable to it. Some seem to resist the action of mercury altogether in this respect, others are affected by exceedingly small doses; and between these two extremes there are great variations in the effects produced by mercury compounds. Salivation may in its more severe forms produce most alarming symptoms. The face swells, the eyes are closed, the tongue may swell so as almost to produce suffocation, ulceration of the throat may occur; exfoliation of the bones, and gangrene and death may ensue from this secondary action of mercury. Now, inasmuch as some persons are more easily acted upon by mercury than others, it is clear that if a small dose of a mercurial salt can produce salivation, and salivation may cause death, a small dose may cause death in this way. And here great difficulties often arise in medico-legal investigation.

To pursue this part of the subject further would lead us beyond the scope of these articles. Suffice it to say that the salts of mercury are all poisonous, primarily or secondarily, and although of great value as medicine *judiciously* used, they may be most dangerous in the hands of unskilled or designing persons. What is the treatment to be pursued in cases of poisoning by corrosive sublimate? Fortunately, it readily forms insoluble compounds with albumen. Albumen is therefore said to be its antidote. When a person has taken this poison, either by accident or design, or has

* Case recorded by Dr. Christison.

had it administered with intent to destroy life (this rarely happens, from the difficulty of concealing its peculiarly nauseous taste), the first thing to be done is to freely administer white of egg. M. Thenard, the great French chemist, during his lecture, by mistake drank a strong solution of corrosive sublimate. He immediately discovered what he had done, and made the fact known to his class. The excitement produced was intense. He told them to bring him eggs. Eggs were sought for in every direction; in a few minutes large quantities were obtained by his anxious pupils, and thus the life of this eminent professor was saved. This happened shortly after the discovery of the effects of albumen on corrosive sublimate were discovered by Orfila. A case is also recorded of a gentleman who, by mistake, drank a portion of an alcoholic solution of this substance. He was so alarmed by the taste that he did not finish it. He was, however, seized with a sense of tightness in the throat, burning at the stomach, and purging. Orfila saw him when the symptoms had acquired great severity, having lasted two hours. The administration of white of egg caused a mitigation of his sufferings, and he ultimately recovered.

It is asserted by Peschier, that the white of one egg will render four grains of corrosive sublimate innocuous. Orfila administered to a small dog twelve grains of this poison; after it had acted for about eight minutes, the whites of eight eggs were given; it vomited several times, the pain ceased, and in five days it quite recovered. The white of egg should be beat up in a little water, and it should be given freely, at intervals. A woman, named Rose Maney, poisoned herself with corrosive sublimate; various remedies were tried, but with little benefit. The morning after the poison was taken, the whites of two eggs, beaten up with a little cinnamon water, were given; this dose was repeated every half hour, until she had taken the whites of twelve eggs, when she began to feel easier; and, during the time she had been under this treatment, she had only vomited twice, and other unfavourable symptoms began to disappear. The white of egg treatment was continued until she had taken the whites of thirty-two eggs. She went on progressing favourably, and was eventually cured. Here the albumen was not given till many hours after the poison was first taken. There is another substance which is considered to act as an antidote, namely, gluten. Its properties were discovered by Taddei, an Italian chemist. In administering it, it is usual to mix the gluten with soap, so as to hold it in suspension. If eggs are not at hand, gluten may be thus used. It is easily prepared by

kneading dough, made of flour and water, under a tap from which the water is pouring in a small continuous stream; the starch is washed away from the flour, the gluten remaining behind; and this should be rubbed up with soap, and rinsed with water. From experiments made by Dr. Devergie, it does not seem to be as effective an antidote as albumen, yet the experiments of Professor Taddei show that it forms insoluble compounds with corrosive sublimate, so as to perfectly precipitate it from a solution of that salt. His experiments on animals are on the whole satisfactory, and a case is recorded of the cure of a man, by its means, who had taken seven grains of corrosive sublimate by mistake for calomel. If albumen and gluten cannot be obtained, milk may be given, as it contains casein, which is similar in its action to albumen. Iron filings mixed with gold dust or gold leaf cause the decomposition of corrosive sublimate with precipitation of metallic mercury, which is not a poison; and even iron filings alone produce the same effect. These substances have been tried with excellent results on animals. Opium has the effect of counteracting the action of this poison, but it would be dangerous to administer it in sufficient quantities. This property is due to the meconic acid which it contains. The action of meconic acid is to form insoluble compounds with metallic oxides, when it is combined with a substance such as morphia, forming a salt which is soluble. In most cases of poisoning, immediate resort is had to the stomach-pump. It should, however, be used with the greatest care, if employed at all, in poisoning by corrosive sublimate, the action of that substance being to corrode rapidly the stomach and the passage which leads from it to the mouth, which is called the œsophagus. Every effort should be made by means of emetics to secure the ejection of all matters from the stomach, and these should be given with whatever other antidotes are employed, whether albumen, gluten, milk, or iron filings.

The appearances which the body presents, after death by corrosive sublimate, are similar to those produced by other corrosive poisons; there is ulceration and destruction of the coats of the stomach and intestines. This is more or less marked, according to the quantity of the poison taken. The mercury sometimes gets reduced by the action of substances with which the corrosive sublimate meets, and hence a grey film may be seen, which consists of finely-divided metallic mercury. The detection of corrosive sublimate by analysis is generally not difficult; but owing to the property which it has of uniting with albumen and similar substances, the process may be somewhat complicated. The method of

separating it out from organic mixtures will be explained, when the separation of other poisons from such substances is treated of. The ordinary reactions by which corrosive sublimate is distinguished are highly characteristic. The salt, being much more soluble in ether than in water, is easily separated from it by shaking up the solution for a short time with ether. The etherial solution floats on the top of the water, and is easily drawn off by means of a pipette; if allowed to flow on a glass plate, the ether shortly evaporates, leaving the corrosive sublimate in beautiful crystals, of a stellate form.

To the crystals thus obtained the various tests about to be described may be applied. Should any of a liquid, supposed to be part of that taken by a person suffering from poison, be found, it should be at once submitted to this treatment; and if a crystalline film be formed on a glass plate, the presumption would be that the poison was corrosive sublimate. If, however, the substance was in the solid form as a white powder, the best method would be to place a small quantity on a piece of glass, and gently warm it, raising the temperature gradually; if the powder was dissipated in dense white fumes, and had a strong metallic odour and taste, and if some of it crystallized on the cool parts of the plate in the forms above described, it might be presumed that the substance was corrosive sublimate. Arsenious acid is also white, but when volatilized by heat its fumes are not so dense, nor does its odour and taste resemble that of corrosive sublimate. Its crystalline form also is different, being octahedral. A solution of mercuric chloride (the chemical name for corrosive sublimate) gives, with a solution of potassic iodide, a very beautiful vermilion-coloured precipitate, which is dissolved by excess either of the iodide or of the mercury salt. This red mercuric iodide, when spread on paper and heated, changes to a yellow colour; but friction restores it to its original tint. When stannous chloride (protochloride of tin) is added to a solution of corrosive sublimate, it takes away chlorine from it in two successive stages. At first a white precipitate is formed, which is mercurious chloride, or calomel. This afterwards changes to a grey colour, from its further reduction to metallic mercury. This is a very delicate reaction, and very small quantities of mercuric chloride may be detected in this way. Moreover, it is not liable to be interfered with or prevented by the presence of other substances which are likely to be met with in the mixture to be tested.

Potash gives, with solutions of mercuric chloride, a yellow precipitate of mercuric oxide; and ammonia, a white precipitate, which

is called in the Pharmacopeia "white precipitate." It is a substitution product, an atom of chlorine in the mercuric chloride being replaced by amidogen. The reaction is represented thus—

$$Hg\ Cl_2 + 2\ (NH_3) = Hg\ NH_2\ Cl + NH_4\ Cl.$$

Hydric sulphide (sulphuretted hydrogen) eventually throws down a black precipitate of mercuric sulphide from a solution of corrosive sublimate. The observer should, however, be careful to watch the changes of colour produced in the solution, as the quantity of hydric sulphide increases. At first the change is to white, the solution gets milky, afterwards it becomes orange-coloured, and at last black. These changes are highly characteristic of mercury. The black sulphide is not soluble in hydric nitrate (nitric acid), and this again distinguishes it from other black sulphides. All these reactions may be applied to the crystalline films obtained by evaporating the etherial solution before described; and all, except the ammonia reaction, will be very apparent. In this case it is advisable to use ammonia sulphide instead of hydric sulphide. They may also be used with the white powder, after the evidence from sublimation has been obtained. It is always necessary, as in testing for arsenic, to obtain the metal mercury. This may be done in two ways. If the substance submitted for examination be a liquid, part of it should be evaporated, on a water bath, to dryness; the residue may then be treated in the same way as if it were found in the state of a powder. The powder should be mixed with carbonate of soda, which has been previously dried by heating it strongly, so as to drive off its water of crystallization. The mixture should then be put into a reduction-tube, such as was described when the method of reducing arsenic to the metallic state was explained, and gently heated; in a few minutes, minute globules of metallic mercury will be seen on the sides of the upper part of the tube. In performing this experiment, the tube should be carefully dried, together with its contents, before applying a heat sufficient to reduce the metal. It will be noticed that some of the white powder is changed to a yellow colour; this is owing to the formation of some mercuric oxide previous to its reduction to the metallic state. It will be remembered that one test for arsenic was its precipitation by copper. Mercury is also precipitated by that metal. If a piece of bright copper be placed in a solution of a mercuric salt, acidulated with hydric-chloride (hydrochloric acid), or if corrosive sublimate in the solid state be rubbed on the copper, moistened with a dilute solution of the same acid liquid, metallic mercury will be deposited on the copper; the film is at first dull, but if it be rubbed gently with a

piece of linen or soft paper, it will have a brilliant metallic lustre. If now the copper be held in the fingers, and be gently passed through the flame of a spirit-lamp, although the heat be not sufficient to cause inconvenience in holding it, the mercury will be volatilized; and this is not the case with any other metal which copper is able to displace from a solution of its salts. If all these reactions be obtained with any substance submitted for examination, they will prove conclusively that that substance contained mercury. It will be now necessary to prove that the substance contained chlorine, for mercuric nitrate, a substance rarely met with except in the laboratory, will give all the reactions already mentioned.

Argentic nitrate (nitrate of silver) gives with all soluble chlorides a white percipitate, dense and flocculent, or rather curdy. This precipitate becomes violet on exposure to light, but it possesses this property in common with most silver salts. It is soluble in ammonia, but insoluble in hydric nitrate. There is a very poisonous salt of mercury, called mercuric cyanide, which is formed by the action of prussic acid (a deadly poison) on mercuric oxide. When a solution of mercuric cyanide is treated with argentic nitrate, a white percipitate similar to that formed with a chloride is thrown down, and this precipitate is soluble in ammonia, also on boiling in strong hydric nitrate, but not in cold hydric nitrate. Now, inasmuch as the poison employed *might* have been mercuric cyanide, it is necessary to distinguish between this and corrosive sublimate. In order to do this, the silver precipitate should be subjected to the action of heat; if it melts or fuses it is argentic chloride, if it is decomposed, leaving only a dark residue of metallic silver, it is a cyanide. If the fused residue be treated with zinc and hydric sulphate (sulphuric acid) in the presence of water, the zinc touching the fused chloride, by electrolytic action silver will be deposited in contact with the zinc, and chlorine will unite with the zinc, forming zinc chloride, and the presence of chlorine in the solution may be detected by argentic nitrate. A still further confirmation of the presence of chlorine may be obtained by adding to the solution supposed to contain corrosive sublimate, some manganic binoxide and hydric sulphate, when, if that substance be present, chlorine gas will be evolved on the application of a gentle heat, and may be detected, either by its peculiar odour, or its action in bleaching moist litmus paper.

The metal mercury is not a poison, that is, when taken in the liquid state. Dr. Taylor mentions that a person, who suffered from obstinate constipation, took as much as half a pound of fluid mercury in five days, without its producing bad effects.

Dr. Daniel Turner, who lived in the reign of Charles II., in his "Treatise on Diseases of the Skin, and the Antient Physicians' Legacy Impartially Surveyed," in speaking of quicksilver, says: "In King Charles II.'s reign, I very well remember, though it is above fifty years past, a physician knighted by that prince, whose name I can sometimes recollect, though not at this moment, encouraged it much, who lived retired somewhere about Edmonton, and when the villagers round coming to consult him, especially on their children's diseases, he advised a thimbleful of quicksilver to be given them every morning for a month." The beauties of the court of King Charles II. used to take crude mercury as an alterative; and it was common to take a teaspoonful, morning and evening, to beautify the complexion, to remove a freckle, or to give a pearly lustre to the skin. It was found that the mercury passed unchanged through the system, and that too with considerable rapidity. But those who are exposed to the action of *vapour* of mercury, or who are much engaged in handling it, often suffer from it very materially. Its effects on miners are often very severe. Dr. John Wilkins, in the "Philosophical Transactions," in the year 1666, in which he describes the quicksilver mines at Priuli, in the Venetian territory, says that, although the miners stay underground only six hours at a time, all of them die hectic, or become paralytic. He saw there a man, who had not been in the mines above half a year before, so full of mercury, that on putting a piece of brass in his mouth, or rubbing it between his fingers, it immediately became white like silver, and so paralytic was the unfortunate man that he could not, with both his hands, carry a glass half full of wine to his lips without spilling it—though the doctor quaintly adds, he loved the wine too well to throw it away. Shaking palsy, and salivation appear to be the consequences of exposure to the vapour of mercury. Barometer makers and looking-glass silverers are both liable to these affections. Dr. Christison relates a case of a barometer maker and one of his men who were exposed one night, during sleep, to the vapours of mercury from a pot on a stove in which a fire had been accidentally lighted. They were both most severely affected, one with salivation, which caused the loss of all his teeth, the other with shaking palsy, which lasted to the end of his life. Chemists who have to work much with metallic mercury often suffer from the effects.

The medicine known as calomel, which is a chloride of mercury, containing less chlorine than corrosive sublimate, has been found to

act as an irritant poison. The poisonous effects of calomel have been attributed to the presence of corrosive sublimate, an impurity not unlikely to occur from the method of its manufacture. It has been stated that corrosive sublimate is made by heating mercuric sulphate with common salt; calomel is made in the same manner, only that an equivalent quantity of mercury is added. Both substances are volatile, and it is therefore very possible that some corrosive sublimate might pass over with the calomel. However, such care is taken in the manufacture of this important drug, that this impurity is rarely found in it. Dr. Christison examined ten specimens, and found but the merest trace of corrosive sublimate in them.

Two cases are mentioned by Hoffman in which fifteen grains of calomel proved fatal to two boys, aged twelve and fifteen. One of them had vomiting and tremors of the hands and feet, and died on the sixth day. The other died after suffering from extreme anxiety and black vomiting. It is clear that very large doses of calomel may be taken without producing poisonous effects. In the East it is used not only as an irritant, but in large doses a sedative. In yellow fever it has been given in doses of from ten to twenty grains four times a day. A strong, healthy girl took an ounce of calomel by mistake, thinking it was magnesia; it was mixed with milk. After some hours the mistake was discovered. Emetics were given. She had previously suffered slightly from nausea and faintness. After a time severe griping pains set in, and there was much tenderness of the abdomen. In four days she recovered, and strange to say, she escaped salivation. Since calomel has acted as a poison, it is necessary to notice the method of its action. Its effects are those of an irritant poison, though it may destroy life by causing gangrene of the mouth and throat. Chemically, calomel has some re-actions different from corrosive sublimate. It is a dense white powder of a slightly buff tint; it is not soluble in water, neither in ether, nor in alcohol. When boiled with strong hydric nitrate it is decomposed. Corrosive sublimate and mercuric nitrate being formed, and both being soluble, are dissolved in water. Hydric chloride partially dissolves it by forming mercuric chloride, and metallic mercury is precipitated. When calomel is heated in a tube it sublimes, and, unlike corrosive sublimates, it is deposited in the cool part as an apparently amorphous powder, which is really crystalline, though the crystals are too minute for detection. If acted upon with potash, it gives a black substance, mercurious oxide, containing 400 parts by weight of mercury to 16 of oxygen,

whereas corrosive sublimate gives the higher oxide, which is yellow. A solution of potassic iodide changes it to a dirty, yellowish, green colour. Ammonia turns it black, instead of forming with it a white compound, as it does with corrosive sublimate, although the substitution which takes place is of a similar kind, one atom of chlorine being replaced by one atom of amidogen.

$$Hg_2\ Cl_2 + 2(NH_3) = Hg_2\ NH_2\ Cl + NH_4\ Cl.$$

Ammonic sulphide also changes it to a black colour, forming the sulphide. Stannous chloride reduces it to metallic mercury, and in this respect resembles its action, in the second stage, on mercuric chloride. It is reduced to metallic mercury when heated with dry sodic carbonate, also when it is rubbed with a dilute solution of hydric chloride or copper.

Its chlorine can be detected by argentic nitrate, but the calomel must first be boiled with a solution of potassic or sodic hydrate, which solution must be rendered slightly acid with hydric nitrate after filtration. The acid liquid is added to combine with excess of potash, which would, if in the state of hydrate, precipitate from the argentic nitrate brown argentic oxide. It will be well to notice briefly the other salts of mercury which have occasionally been used as poisons. The red oxide, mercuric oxide, which contains 200 parts of mercury and 16 of oxygen, is usually prepared by cautiously heating mercuric nitrate. It is in appearance of a scaly nature, and bright scarlet colour; when heated it changes to a chocolate brown, and eventually becomes black; on exposure to air it recovers its red colour again. If, however, the temperature be raised considerably, it is decomposed into oxygen and mercury, which volatilizes, and is condensed in the cool part of the tube in minute brilliant globules. This red oxide is used in medicine, generally as an ointment; it is also employed, mixed with fat, for the destruction of vermin which infest bedsteads. Several cases of poisoning by this substance are recorded; the symptoms resemble very much those which have been described as produced by other preparations of mercury. The quantity required to cause death seems to be large, thirty grains have been taken without producing serious consequences. The best treatment appears to be the administration of emetics and demulcent drinks with albumen or gluten. Cinnabar or mercuric sulphide, the black sulphide of mercury precipitated by hydric sulphide, as already described, when dried and heated, sublimes, forming the red sulphide; they are identical in their chemical composition. Cinnabar is the principal ore of mercury, it occurs crystallized in six-sided prisms.

The paint called vermilion consists of this sulphide artificially prepared. The methods of preparation differ in different places, and with different makers, but all are the same in principle. Animals have been killed by its action, even when it has been applied to wounds. There is no instance on record of a human life having been destroyed by it. Mercuric sulphide contains mercury and sulphur in the proportion of 200 parts of mercury to 32 parts of sulphur, by weight. When heated it is decomposed, metallic mercury and sulphur being sublimed separately. The best way, however, to decompose it is by the action of finely-divided iron, which unites with the sulphur, the mercury being set free on the application of heat; and it may be proved that sulphur was in combination with the mercury by treating the iron compound with hydric sulphate, when hydric sulphide is evolved, which may be detected by its odour, or by its blackening paper moistened with plumbic acetate; or, if the quantity be too small to give this reaction distinctly, its presence may be known by the beautiful purple colour which it gives with an alkaline solution of sodic nitroprusside.

Turpeth mineral is a yellow basic sulphate of mercury. But few cases of poisoning by this substance are recorded. It is obtained by acting on the normal white sulphate with water. It is very heavy, and has an acrid taste. When heated the mercury is sublimed, and sulphurous acid is given off, which may be detected by its smelling like burning sulphur. If boiled with caustic potash, potassic sulphate is formed, and mercuric oxide precipitated. The sulphate can be detected by its giving a white precipitate with a soluble baryta salt, which is insoluble in all acid liquids. The mercury can be detected by the reactions already described.

Mercuric cyanide has been already alluded to. Cases are on record of persons having been poisoned with this salt. It is easily detected by the action on it of heat; it is decomposed into mercury and cyanogen gas; the cyanogen burns with a very beautiful rose-coloured flame. It is hardly necessary to mention the nitrates; the action of mercuric nitrate on the human frame is the same as that of corrosive sublimate. It is detected by the same tests, except that the nitric acid gives no precipitate with argentic nitrate, and is to be sought for in another way. If the mercury be precipitated with potash, potassic nitrate will remain in solution, and this, when evaporated to dryness with organic matter, detonates if brought to a red heat. It is better, however, to add to some of the liquid an equal volume of hydric sulphate, and after the mixture

has become quite cold, to pour on it carefully a solution of ferrous sulphate. Where the two liquids join, a brown-coloured ring will be formed.

Poisoning by copper is very rare, except as the result of accident, yet very serious effects have been produced by taking salts of this metal. It is largely used in the manufacture of saucepans and cooking utensils, and was, not many years ago, put into pickles, to increase the green freshness of their colour. It is often employed by confectioners for colouring their sweetmeats, and the decorations they use for ornamenting cakes. It is found in combination with arsenic in some of the green colours of the paint-box; and the colours known as verdigris and verditer are preparations of the acetate and carbonate of copper.

The salts of copper are rarely used by the poisoner, because they have a deep and well-marked colour, and a very acrid taste. The general colour of cupric salts is blue or green. Blue stone (blue vitriol), the sulphate is of a bluish green colour, the nitrate is of a deeper blue, and the chloride is green. The metal copper does not seem to be poisonous, but, when taken into the stomach, it meets with acid liquids, by which it may be oxidized and dissolved. Dr. Taylor relates the case of a boy who was engaged in printing gold letters—the gold employed is an alloy of copper—this substance reduced to a fine dust, floats about in the air; the boy inhaled these particles, and on the third day was seized with vomiting of a green coloured fluid, with heat and constriction in the œsophagus, pain in the stomach, loss of appetite and rest, and with a severe itching of the skin in those parts covered by hair, which parts were changed to a deep blue colour. About twelve persons engaged in the same employment were similarly affected. The use of copper cooking utensils is not objectionable, if they be kept clean, but certain substances employed in cooking have a tendency to dissolve the metal. Oils and fatty matters have this action. It has been said that they must first become rancid, but this is not the case. Fresh butter has been found to act on copper, and the surface of a copper plate has become blackened in twenty-four hours, when covered by that substance, and the butter itself has become green; this only occurred when it was in contact both with the air and the copper. One therefore concludes that the presence of air is necessary to produce this result. Dr. Christison says that, in fresh hog's lard, he has found that the whole lard in contact with the copper becomes blue, even to a depth to which the air can scarcely reach. Hot oil acts in a similar manner; one knows the effects produced in old

fashioned brass lamps, where the oil which remained in the receiver for the drippings, was almost invariably green. Vinegar dissolves copper, and the vegetable acids generally, in the presence of atmospheric air. It seems to be necessary to keep the metal covered with the fluid, and then these effects are not produced. It is, however, most dangerous to allow any acid substances that are to be used for food, to stand for any length of time in copper vessels. Preserves are usually made in copper or bronze pans; these should be emptied out as soon as the operation is completed, and the pans should be well cleaned, as the fruit acids would inevitably oxidize and form poisonous salts with the copper. A case is recorded in "Wildberg's Practical Manual," of a servant who left some sour krout, for only two hours, in a copper pan, which had lost its tinning. Her mistress and a daughter, who took the cabbage at dinner, died after twelve hours illness, and Wildberg found the cabbage so strongly impregnated with copper, that it was readily precipitated on iron. Any amount of carelessness, in the use of copper vessels, on the part of servants, may be attended with very serious results, so that it seems almost advisable to abandon their use in favour of iron ones, which are not liable to these objections. A case is related by Gmelin, of a whole community of monks who were attacked by a violent disease, the symptoms were those which result from copper poisoning. On inquiry, it was found that every utensil in the kitchen and dairy was made of copper.

A LIFE-HISTORY.

BY THE REV. THOMAS HINCKS, B.A.

It is my purpose in the present paper, through a somewhat minute study of a single species, to convey an accurate idea of the type of structure which is characteristic of a large and interesting group of animals. If I can succeed in portraying—not in technical phraseology which only a few can interpret, but in popular language, intelligible to all—the living form which I have selected as my example, in sketching the history of its birth and development, and the customs of its life, I shall not only put my readers in possession of an individual biography, but also supply them with a key to the organization and economy of an important tribe. After all, one of the best and pleasantest ways of teaching zoology is through biography—the story of representative lives told with fidelity and thoroughness, and, if it may be, with vivacity too.

For technical diagnosis then, let us substitute a picture from the life, and for the severe definitions of the systematist the warm colours of nature.

The group which I propose to illustrate by means of a representative form is that section of the *Zoophytes*, of which the common *Hydra* is the type. When the Radiate division in Cuvier's classification was dismembered, and its heterogeneous tribes were redistributed, the Hydroids, the corals and sea-anemones, and the jelly-fishes of all grades, amongst which one distinctive plan of structure is easily traceable, were united in a new sub-kingdom, to which the name *Cœlenterata* was assigned.* This great race divides itself naturally into two principal branches, one of which has the closest affinity with the *Hydra*, the other with the *Actinia*—the *Hydra-class* and the *Actinia-class*. Each of these larger groups again subdivides into several orders, in which the typical characters are variously modified. To that section of the *Hydra-class* (*Hydrozoa*), which exhibits the least amount of divergence from the type-form (*Hydra*), the subject of the present sketch belongs; its name is *Clavatella prolifera*. So much as an indication of systematic position; let us now pursue the life-history.

And first as to the habitat of our Hydroid; those who are familiar with the beautiful shores of Torbay will remember that at many points the beach is strewn with large blocks of limestone, the

* In an ingenious paper, recently published, Haeckel asserts the close relationship of the *Sponges* and *Corals*, and proposes to include the former amongst the *Cœlenterata*.

debris of the overhanging cliffs. These detached masses, long exposed to the action of wind and wave, are sculptured into picturesque shapes, whilst the surface is worn into a multitude of little basin-like hollows, in which whole populations find a home. When the tide recedes, they form a most productive hunting-ground for the collector, who will not soon exhaust the fauna and flora of the little pools that lie here and there, like miniature tarns, on their rugged sides. These rock-basins are never left dry; when the tide is out their waters are exposed to the genial influence of the sun; when it flows they are renovated and freshened by the dash of the incoming waves. They offer a large amount of shelter and warmth, combined with constant supplies of the purest ocean-water; and they are consequently rich in life, and rich especially in the more minute and delicate forms both of animal and plant. Some of these pools are deep and narrow, and their sides are clothed with a dense vegetation; others are shallow and comparatively open, and in these the growth of *Algæ* is often scanty, a few tufts of the red Coralline, and of a slender green conferva relieving the barrenness of the rocky floor. Animal life, however, there is in abundance, even in these shallow waters; the pretty Daisy-anemone (*Sagartia bellis*) crowded in the chinks and crannies, opens its festooned, flower-like discs to the sun; colonies of the charming little compound *Actinia, Zoanthus sulcatus,* stud the bottom, hardly distinguishable from the delicate tufts of Algæ; forests of a graceful zoophyte (*Campanularia flexuosa*) spread luxuriantly in all directions; the Acorn-shell (*Balanus*) roughens the surface of the rock; the stealthy limpet glides slowly about in search of pasturage, while multitudes of minute Annelids protrude from their burrows, their rapid and restless movements contrasting with the still life around them. These shallow pools, with scanty vegetation, lying within the higher zone of the limestone blocks, fully exposed both to the sun and to the sweep of the flowing tide, are the haunts of the *Clavatella*.* It is very constant in its choice of habitat, seldom, if ever, occurring in the lower rock-basins, or in those that are much overgrown with

* Another habitat of the *Clavatella* may be mentioned. On the well-known Capstone at Ilfracombe it occurs plentifully in such shallow pools as I have just described, lying on the upper ledges and plateaux, exposed to the dash of the tremendous seas which break over this noble pile of rock; open, too, to the freshest winds, and reflecting the smile of the most genial sunshine. In these bright pellucid waters the little Polypites may be seen on the summer day (by those who *can* see), displaying all their beauty, in hot pursuit of the Cyclops and the worm. Amidst the turmoil of the incoming tide, when tons of troubled water are heaved upon their lately quiet dwelling-places, the remarkable contractility of their bodies must enable them to shrink into mere specks, and so escape the destruction which falls upon larger and stronger things around them.

weed. But to find it is by no means an easy task, even when its favourite haunts are known. Patiently scanning the bottom of one of the pools in a strong light and with a keen eye, you may notice in some little hollow, or at the base of one of the small tufts of sea-weed, what seem to be extremely fine milk-white threads. You would hardly take them to be animals, but might probably pass them by as the bleached filaments of some minute Alga. But if you watch them closely for a while, you will see that the thread-like bodies exhibit definite movements, now contracting, now extending themselves, now swaying to and fro; and if a lens be brought to bear upon them, you will find that you have before you a colony of most exquisite polypites,* minims, indeed, in size, but endowed with the most perfect beauty of form and grace of motion (Fig. 1).

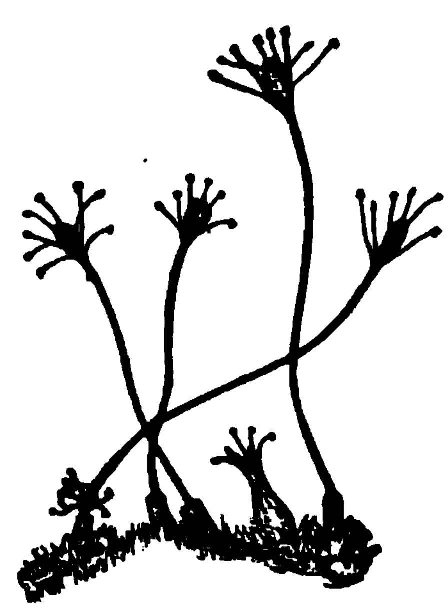


FIG. 1.

Rooted to one spot, their life runs its course within the limits of the little pool in which we find them. In their adult condition they are as stationary as the *Balanus* or the weed. It will be convenient to give a detailed description of them before proceeding to consider their habit of life, dealing first with form and general aspect, and then with internal structure. In the former we shall recognize the features of the individual species; in the latter, the characteristics of the class and sub-kingdom to which it belongs.

The colonies of *Clavatella* are generally of small extent, composed of a few *polypites* rising from a delicate creeping fibre, which links them all together, and at the same time binds them to the surface of the rock. This portion of the structure is difficult to detect, as it is commonly concealed by an undergrowth of minute vegetation. It consists of a slender thread of animal substance, encased in a somewhat membranous covering (the *polypary*), which is prolonged into a small tubular sheath round the base of each polypite (*vide* Fig. 1). This thread-like base supports the colony, and also provides for its increase; as it grows and spreads it glues itself to the rock, and every here and there gives origin to buds, which develope themselves into fresh polypites; and so, by a truly vegetative process, the little commonwealth enlarges its boundaries and adds to the number of its members. The delicate sheathing that invests

* The term *polype* is now restricted to the animals of the *Actinozoa*—the Actiniæ and Corals; the alimentary zooids of the *Hydroida* are known as *polypites*.

the creeping stem and the base of the polypites (Fig. 2, *p, p*), is the representative of the more substantial horny polypary, which in other sections of the *Hydroida* involves the whole of the soft portions, and which attains its highest development in the graceful arborescent forms of the Sertularian Zoophytes. The polypites of *Clavatella* are unprotected by any hard covering;* but they are endowed with remarkable contractility, and can shrink down in a moment within the shelter of the surrounding Algæ, or into some cranny in the rock. When extended, the body is slender and thread-like, enlarging gradually towards the upper extremity so as to present a somewhat clavate figure. At the top a small orifice or mouth (Fig. 2, *m*), opens directly into the stomach; and at a short distance below it, the body is encircled by a wreath of extensile arms or tentacles, whose office it is to capture the minute creatures on which the *Clavatella* feeds, and to convey them to the mouth (Fig. 2, *t t*). The clavate extremity of the body, bearing the mouth, and inclosed within the whorl of tentacles, forms a kind of proboscis (Fig. 2, *pr*), which can be moved freely in all directions, and is capable of great elongation and contraction. It is employed in seizing the prey which the arms have arrested, and brought within reach. The tentacles of *Clavatella* are weapons of offence and prehensile organs; they consist of a slender extensile stem, surmounted by a large globular head, in which a whole battery of thread-cells is lodged. Capable of great elongation, of quick movement in all directions, of vigorous percussive action, and charged with a multitude of poisoned darts, they literally

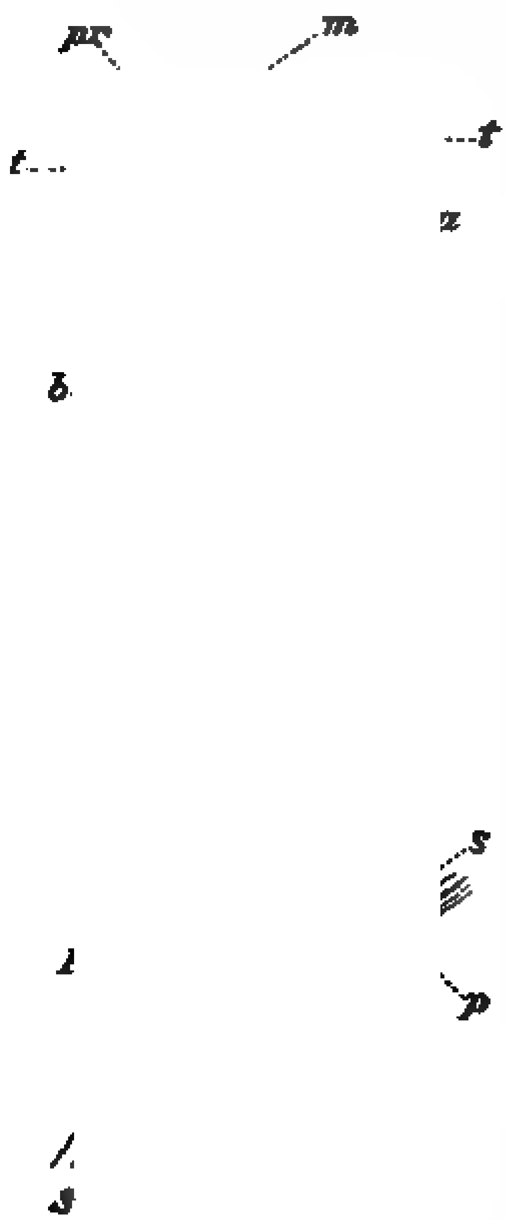


Fig. 2.

* The three sub-groups into which the Order *Hydroida* is divided are founded on the absence or presence of a polypary, and on the degree of its development. The *Gymnochroa* are altogether destitute of a solid covering; the *Athecata* have a polypary, but no protective case or calycle for the polypite. Amongst the *Thecaphora*, the common flesh is sheathed in a horny covering, and the polypites are lodged in calycles or horny cups. *Clavatella* ranks in the second of these divisions.

pursue, strike down, and seize the minute but active *Crustacea* and other creatures, which form the food of the Hydroid. In their work as purveyors they are assisted by the extensibility of the lithe and limber body, which stretches itself out eagerly in pursuit of prey, and twists itself about, not without much exquisite grace, to meet the exigencies of the hunt.

The *thread-cell* is a piece of structure very characteristic of the sub-kingdom to which *Clavatella* belongs, though not absolutely confined to it. It may be described as a minute sac imbedded in the outer layer of the flesh, and inclosing a long thread-like dart, which can be projected with much force; piercing its victim, it seems to poison as well as to wound. The thread-cells are present on all the Hydrozoa, and often in immense numbers; they are always aggregated in batteries on the tentacles, and enable the stationary Zoophyte to deal with the nimble tribes that serve as its food.

The slender body of the *Clavatella* is of an opaque-white colour, and when most fully extended—attenuated into a mere hair-like filament—is about one-third of an inch in length.

The structure, in its general and superficial characteristics, as we have now described it, is that of all the *Hydroida;* the disposition of its knobbed tentacles in a single verticil, and its reproductive peculiarities, which we shall notice hereafter, separate *Clavatella* generically from others of its tribe; but these are only slight modifications of the common type. In realizing its form, the plan of its organization, and the manner of its life, we have a key to the structural history and the habits of its race.

But we must now proceed a step further. Having sketched the *Clavatella*-colony planted on the outskirts of the little grove of Algæ in some crystal pool, we have next to examine the material of which it is formed, and the plan of its internal structure. The polypite is nothing more than a stomach, and an apparatus of prehensile organs for the supply of food; its whole interior is occupied by a simple digestive cavity (Fig. 2, *c*), which is bounded immediately by the main body-wall. This wall, the substance out of which the entire structure is wrought, is composed essentially of two distinct layers —an outer (Fig. 2, *a*,) and an inner (Fig. 2, *b*), the latter lining the cavity of the body, the former constituting its external covering.* From these two layers, by differentiation, all the other forms of structure are developed; the outer giving origin to the solid pro-

* In *Clavatella* the outer layer is transparent, and allows the inner, which is laden with opaque-white granules to be seen through it.

tective covering (Fig. 2, *p*), to the thread-cells, and to whatever organs of sense or motion the polypite may possess; the inner supplying all that is concerned in nutrition and reproduction.

The whole Clavatella colony, comprising the polypites and the connecting thread that binds them all together, is built up out of these two lamellæ;* and they are also the primitive and essential elements of *all* Cœlenterate structure. We lay bare here the foundations of the great sub-kingdom, of which our little Hydroid is a humble member.

Another structural feature is of high significance. The stomach of the polypite, the perfect simplicity of which has been noticed before, is not closed at the base, but communicates freely through an orifice with a canal which traverses the whole of the common connecting flesh (Fig. 2, *d*). This canal is indeed a continuation of the digestive cavity, and serves to convey the nutriment prepared by the individual polypites to all portions of the organism. It is the channel by which in our little *Clavatella* the supporting base of the colony is supplied with the nutrient fluid; within which, in the large arborescent Zoophytes the food, elaborated by a multitude of busy workers, is borne in a rapid stream through all the complex ramifications of the plant-like animal. This free communication between the stomach and the general cavity of the body—a striking feature both under its structural and physiological aspects—is the second of the great fundamental distinctions of the Cœlenterate sub-kingdom. In the two points just referred to, *Clavatella,* with all its marked individuality, is absolutely identified with the large miscellaneous host, including the *Sertularians* and the *Medusæ,* the *Actinia,* the *Coral,* and the *Beroe.* By these two characteristics it is also set apart from all the other primary groups of the Animal Kingdom.

I have endeavoured to picture the external appearance of the *Clavatella*-colony, and to describe the leading features of its structure. Let us now consider some of the vital processes of which it is the sphere. A slight physiological survey will suffice to disclose the points of special significance.

And first as to nutrition—each polypite is a fisher and feeder for the commonwealth; the food which it captures and digests is not for its own nourishment only, but for that of the colony to which it belongs. A circulation of the most primitive kind, so to speak, is carried on within the general cavity of the body (Fig. 2, *d*), by

* The whole Hydroid community may be described as "a double-walled, branching tube." [Agassiz.]

means of which the pabulum prepared in the various stomachs is distributed throughout the whole structure. A nutrient stream, laden with granules, is seen to flow along the course of the common canal, entering each polypite in turn through the opening at the base of the stomach and mingling with the contents; after thus traversing the colony in one direction, and charging itself with the nutritive elements, it flows back again, fertilizing as it goes. This simple arrangement, this flux and reflux of the chymiferous fluid, which renews itself by repeated visits to the numerous depôts of food, is in the place of all the complex systems of secretion and circulation in the higher animals. It may naturally be asked, how, in the absence of a heart or propulsive organ, the flow of the nutrient juices is maintained. The main agents in effecting it are no doubt the cilia which cover the inner surface of the lining membrane, assisted, it may be, by the contractility of the walls of the digestive cavity. There is little specialization of organs in these humble beings; the fluids are kept in circulation by thousands of cilia distributed throughout the cavity of the body, and in like manner the respiratory function is provided for by the general action of the highly oxygenized sea-water, and not through any specific structure.

Then as to growth, the *Clavatella*-colony is extended by a vegetative process; its composite organism, like the more complex tree, is the product of continuous gemmation. The primary polypite, the first unit of the commonwealth, gives origin to the creeping stem which buds from its base; and from this stem the other polypites are developed successively, until the colony is complete. In the present case the habit is of the simplest kind; the polypites are sessile, there is no intricate branching, no luxuriance of growth. *Clavatella* may be called a dwarf herbaceous zoophyte. The large complex arborescent kinds in which the tall shoots support their hundreds of polypites, have their parallel in the forest tree. The Hydroid colony is the product of an indefinite repetition of similar parts. There are few solitary species, for the vegetative tendencies of the race are seldom suppressed. Even the *Hydra*, which remains single, is an inveterate budder, and if it could retain its offshoots in connection with itself, instead of turning them adrift, would rival the most tree-like of its tribe.

If we examine the bud put forth by the creeping stem, and which is to become a polypite in time, we shall find that it is a mere bulging of the double-wall, forming a little closed sac, into which the nutrient current penetrates. Indeed, in such new portions of the

colony the circulation is peculiarly active, and large quantities of granular matter (*building material* as it were) are borne to them. This sac-like extension of the stem-wall gradually lengthens; when a certain stage of growth has been reached, two tentacles begin to bud at opposite points on its surface, and others follow until the full number is complete. Before they are all developed, however, the summit of the sac opens, and the new polypite having thus obtained a mouth, proceeds at once to supply it, and contribute its quota to the nutrition of the colony.

This rapid sketch may perhaps give some general idea of the interior economy of Hydroid life, and we must now pass on to the last and, in some respects, most interesting chapter of our history, that which relates to the reproduction of the species.

Amongst the *Hydrozoa* (or zoophytes of the *Hydra* class) to one section of which our *Clavatella* belongs, the functions of alimentation and reproduction are assigned to different members of the community. There is a class that is charged with the nutrition of the individual colony, and another that is charged with the propagation of the species; just as leaf-buds and flower-buds, dissimilar in structure and appearance, and performing different offices, are united in the organism of the plant. The polypites, the feeding-class, have already been described; let us now glance at the reproductive members of the *Clavatella*-colony.

The flower-bud of the plant, as we know, is fixed, and matures and scatters its seed *in situ;* the flower-bud, so to speak, of the zoophyte is also sometimes fixed, but, in many cases, it is organized for independent existence, and at a certain stage of its development detaches itself from the community, and becomes free and locomotive. In this condition it presents a striking contrast both in external appearance and habit of life to the sedentary stock from which it sprung. It would be a parallel case, if the flower were to escape from its stem and float like the insect in the air, till its seed was ripened and discharged. *Clavatella* is one of the species in which the reproductive members* of the colony are free.

The sexual buds, like the flowers of the plant, are developed at certain seasons only, and occupy a definite position in the colony. In *Clavatella* they occur at two points, near the lower extremity of the body of the polypite, where they hang in opposite clusters.† During the spring and summer they are developed in great numbers,

* If any one prefers a Greek term, he may style them *gonozooids.*

† In Fig. 1, they are represented on the body of the polypite which is stretching to one side, as if in pursuit of prey.

but towards autumn the reproductive season comes to an end, and the zoophyte returns to its merely vegetative condition. These male and female buds (for they may be of either sex) are not distinguishable at first, except by their position, from those that are to become polypites; but they soon enter upon a different line of development, and show that they are bound for another goal. At the same time they show as clearly that they are structurally allied to the polypite—that they are, indeed, *polypites with a difference.* I shall not attempt to follow them through all their stages; but after a time one in each cluster is found to be much ahead of its companions, while the vigour and vivacity of its movements seem to show that it has attained its majority. It is attached to the body of the polypite by a short and slender stalk, on which it twists itself about with much vehemence, as if it were seeking (as indeed it is) to sever its connection with the parent stock, and break away into free life. In a short time its efforts are successful; the frail bond gives way, and it ceases to be an integral part of the colony. Fig. 3 is a representation of it as it appears at this stage. At first sight it seems to bear little external resemblance to the stationary brethren from which it has just parted. But let us see; we may perhaps trace a family likeness after all. Its body is hemispherical in shape and of a yellowish white colour; from the margin of its inferior surface spring a number of arms or tentacles (usually six) that bear, in some respects, the closest resemblance to those of the polypite, but also exhibit a difference which has a special significance. They are forked instead of being simple (Fig. 4); one of the two branches into which they divide, bears the globular head with its battery of thread-cells (Fig. 4, *a*), the other terminates in a suctorial disc (Fig. 4, *b*), which adheres tenaciously to any surface to which it may be applied. These arms are plainly for manifold uses; they are organs of locomotion, as well as instruments offensive and prehensile. In the centre of the lower surface of

FIG. 3.

FIG. 4.

the body, and surrounded by the tentacles is a proboscis (Fig. 3, *p*), which supports the mouth and corresponds with the similar structure in the polypite. Set round the body at the points of junction with the arms are a number of dark red spots (Fig. 4, *c*),—masses of pigment in which a minute crystal is imbedded—which we may safely regard as simple organs of sense, and probably as the equivalent of the eyes of the higher animals. Before its separation from the parent-colony, this curious organism, as I have mentioned, is borne on a short stalk, which is attached to the rounded (or upper*) side of its body; at this time the mouth and arms are turned upwards, and as it sways to and fro on its slender support it bears a general resemblance to a polypite which has not yet attained its full proportions. The forked arms and the eye-like specks, however, are significant points of difference. When it has detached itself it reverses its position; the mouth is turned *downward*, and by means of the sucker-bearing limbs of the tentacles it strides slowly along, the branches which carry the thread-cells being left free for the pursuit and capture of prey. In this free sexual member of the *Clavatella*-colony we may recognize in spite of its adaptive disguise, a polypite modified for independent existence; the long, stem-like body being suppressed, suctorial discs being appended to the tentacles to serve as feet, and certain organs of sense being superadded as a provision for its wandering life. It should be mentioned that it is also furnished with a simple system of vessels for the distribution of the nutrient fluid.

We have then before us the ambulatory member of the *Clavatella*-colony, charged with the reproductive function, sent forth to mature and scatter the seed of new communities. Leaving its sedentary brethren to vegetate beside the Algæ, it enters upon a free and active life through the various phases of which we must now follow it.

I have said that it strides along on its suctorial feet, and I may add that its gait is peculiar, and that its movements are full of *character*. It can ascend a perpendicular surface with perfect ease, much in the same way as a star-fish does, to which indeed it bears a considerable resemblance. It is an agile climber, and is to a large extent arboreal in its habits, spending much of its time amongst the filaments of a bright-green confervoid Alga, to which it clings by means of its suckers, and so lies in wait for prey. What a contrast it offers, perched up aloft, or passing from stem to

* *Upper* after its liberation; but the *lower* before it.

stem in search of food, to its graceful brethren rooted in the hollow below!

It soon however betrays its affinities, and shows that it comes of a vegetative race; buds begin to germinate round the margin of the body in the spaces between the tentacles, which are gradually developed into the likeness of their parent, and at last detach themselves and repeat its manner of life. Frequently, too, gemmation commences in the young before its separation, and three generations are for the time organically united. In all this we have a reminder of the plant-like Hydroids, and their famous type the Hydra.

This multiplication by budding, which takes place in the earlier part of the spring, is a most prolific process; indeed, it is difficult to set a limit to it, and an immense number of these propagators of their species must be the final product of each colony. If the progeny maintain the same rate of increase as the parent, an individual would soon be represented by some thousands of descendants.* Many, no doubt, fall a prey to other animals, and perish in various ways; but making every allowance for loss, the provision for the continuance of the species must be ample indeed.

The budding is almost confined to the early part of the spring; as the season advances it gives way to a true sexual reproduction. The male individuals—I use the latter term in a popular, and not in a zoological sense—are much less common than the female; indeed, they seem to be rarely met with. The latter are found at the proper time laden with the eggs, which are produced in the upper portion of the body (Fig. 3, *o*), between the two layers of the body-wall, to which I have before referred as characteristic of all Cœlenterate structure. As they increase in size they form a prominent hump on the upper side, and materially affect the shape; soon they are developed into perfect embryos, and lie awaiting their escape.

We now reach the closing scene of the life-history. As its load increases, the activity of the zooid† begins to decline, and at last it passes into a state of absolute quiescence. Its work is now accomplished; fixing itself firmly by means of its suctorial feet, it remains immovable, the capitate branches of the tentacles standing out rigidly round the body, like the rays of a star-fish. It resumes, in

* Professor F. de Filippi tells us that, in two Aquaria which he had the opportunity of observing, he had found them, during the month of April, "in incalculable numbers," so that the sides of the vessels, and especially those exposed to the light, were covered with them. He was able to examine hundreds, nay thousands, of them in every stage.

† *Zooid* is a very convenient term; it is employed to designate the half-independent elements, which are united in the complex individuality of the Zoophyte, such as the *polypite*, the *gonozooid*, etc.

short, the stationary habits of its race, and in this condition it continues until by the rupture of the walls of the body the brood of embryos is liberated and dispersed, just as the seeds of the plant are set free by the bursting of the seed-vessel. So the reproductive member of the *Clavatella*-colony fulfils its mission, and comes to an end.

The *embryo* of *Clavatella*, as of almost all the Cœlenterata, is a minute ciliated body, bearing a general resemblance to an animalcule, which after a brief term of activity loses its locomotive organs, attaches itself, and is developed into a polypite, from which by repeated buddings the perfect colony is evolved.

I have selected *Clavatella* specially as a representative of its order, the *Hydroida;* and, in a more general way, as an illustration of the plan of Cœlenterate structure. I ought therefore before concluding my history, to mention the points in which it is unique, and differs from all its kindred. It may be taken as in most respects an exponent of their organization and manner of life; but it presents a peculiarity which is both interesting in itself, and also as a clue to the interpretation of certain portions of the general structure. It has been stated that in many of the Hydroid Zoophytes the sexual bodies continue in connection with the colony, like the flower-bud of the plant; but that in many others they become free, and lead an independent life while discharging their reproductive functions. *Clavatella*, however, is the only species known to us in which the sexual zooid is *ambulatory* in its habits.* In all other cases, with one or two exceptions, the reproductive member of the colony, when free, is furnished with a contractile swimming-bell, within which the portion of the body containing the stomach and mouth is suspended; and by the alternate contraction and expansion of this bell, it is driven through the water. In other words, the free sexual zooid of the *Hydroida* is, in a large proportion of cases, *Medusiform*, and has been commonly described as a *Medusa*. It has no rightful claim, however, to a name which seems to imply that it is an independent animal, instead of a mere member of the Hydroid community, detached on special service. The Medusa-like zooid is a floater and swimmer, and of course will secure a much wider range of distribution for the embryos than the ambulatory zooid of *Clavatella*. Unlike however as the two are in their mode of locomotion, the structural differences between them are by no means

* That of *Eleutheria* (Quatrefages), indeed, can drag itself along by means of its tentacles on a flat surface; but it is truly scansorial in its habits.

great. The sexual zooid of *Clavatella* requires but slight modification to change it into a *Medusoid*. Give it a swimming-bell, the elements of which it has in its structure, though otherwise employed, and the conversion is effected. I have already pointed out the close relationship which there is between it and the alimentary member of the *Clavatella*-colony, notwithstanding their dissimilarity in appearance. The ambulatory zooid, therefore, is a most interesting link between the *polypite* (the feeder) and the (so-called) *Medusa* (the reproducer), the two modes of Hydroid structure that seem to be most widely divergent. But these things lie beyond the limit of the plain and simple history which it was my purpose to relate.

The restless embryo, whirling hither and thither in search of a place of settlement; the colony of graceful polypites, linked together in a common life, rooted amongst the Algæ in some pellucid pool, developing new members, as the plant new branches and leaves, bearing too when the time is come its *quasi* flower-buds, and casting them off, when perfect, to ripen and scatter the seed of other colonies; the sexual zooid, freed from the parent-stock, roaming about on its suctorial feet, or climbing amongst the forests of weed in quest of prey, multiplying itself many fold by gemmation, and at last giving origin to a brood of embryos, that start into active existence through its death, and so completing the cycle; these are the principal phases of the being which we have been studying.

If I have at all succeeded in conveying, through this simple sketch, a vivid and accurate conception of this remarkable Life-history, my readers will have in their hands a key to the interpretation of the whole group of Hydroid Zoophytes. Incidentally too, through a living example, the structural bases of the great Cœlenterate sub-kingdom have been brought to their view.

COAL-TAR AND ITS PRODUCTS.

BY EDMUND J. MILLS, D.SC., F.C.S.

(*Continued.*)

In the last article, a sketch was given of a chemical theory of coal-formation, and of the production of tar; and after pointing out the mode of utilizing the aqueous portion of the tar, the oily constituent was alluded to, and attention drawn to its oxygenous constituents. Of these, phenol and some of its derivatives were briefly described; the others (cresol, phlorol, rosolic, and brumolic acid) have not as yet acquired sufficient industrial importance to be at present appropriately discussed.

Hydrocarbons.—This name is applied by chemists to bodies consisting exclusively of hydrogen and carbon. They form a principal constituent of tar proper, or the oily layer, in which they occur very numerously. The most important of this large group of bodies is undoubtedly benzol, a substance which is in many ways exceedingly interesting. As a characteristic ingredient in coal-tar, the relation of its formula ($C_6 H_6$) to that of cellulose ($C_6 H_{12} O_6$) is most suggestive, and strongly confirmatory of those genetic relations of coal itself which have already been detailed—just as the characteristic presence of hexylic hydride ($C_6 H_{14}$) in Boghead petroleum also points to the same conclusion. The history of benzol is somewhat remarkable. In the year 1825 Faraday was occupied with the investigation of certain liquids which were deposited in the cases used for containing compressed oil-gas, a material which was at that time a cheap source of illumination. He was able to detect, in the complex mixture on which he had to work, a body to which, in accordance with the current nomenclature and notation of his time, he gave the name "bicarburet of hydrogen." Several years afterwards, Mitscherlich found that on distilling benzoic acid with lime, a volatile oil came over, and that this was in every respect identical with Faraday's compound. Hence the name "benzol." It was not, however, until 1845 that Hofmann proved the presence of benzol in coal-tar; nor until three years later that Mansfield (unhappily a martyr to these researches) showed how it might be obtained from that source on an industrial scale. A small specimen of Faraday's original preparation is still in existence, sealed up as a recondite curiosity by its discoverer; *now*, benzol is manufactured

by the ton. The direct proportion of power to knowledge could scarcely be illustrated by a more instructive contrast.

Benzol constitutes sometimes as much as one-tenth of the weight of crude tar. In order to prepare it, the *light oil* is used as a starting-point. This material is placed in large stills, and submitted to what is termed "fractional distillation," that is, to a distillation in which the contents of the retort are separated into certain portions, which are distilled over and received separately. The apparatus employed is very simple in principle, and, however varied in form, is generally merely the embodiment of a method first delineated by Mansfield. The retort invariably contains a mixture of hydrocarbons, having a gradually increasing boiling-point, and a gradually increasing chemical complexity. On applying heat so as to cause ebullition, the first "distillate" or substance that arrives at the receiver, will be that which possesses the lowest boiling-point; the next will have the next higher boiling-point, and so on. This law, however, is not more than approximately true, it being always found in practice that a complete separation of the constituents in the retort cannot be effected, each body of lower boiling-point dragging with it, so to speak, some of each body of higher boiling-point. The impurities which would be thus introduced into the distillate necessarily exist in the vapour; but it is found that, by passing the vapour through an upright tube surrounded by baths of various suitable temperatures, they can be *cooled out*, and compelled to run back into the retort, without rising high enough to pass over into the receiver. The benzol of commerce, however, is never pure, its boiling-point being frequently 100°; in fact, a steam-bath is employed in its preparation. Absolutely pure benzol can be obtained by re-distilling commercial benzol at about 80°, and submitting the distillate to the prolonged action of a freezing mixture. It then crystallizes in beautiful white plates, having a high lustre, which melt at about 3°, and from which the impurities can be removed by draining and pressure in a cold apartment. When these crystals are re-melted, they constitute a colourless, highly refractive liquid, of somewhat agreeable odour, boiling at 82°, and considerably lighter than water. The crude or pure product may be used as a solvent of grease-stains, of caoutchouc, gutta percha, and resins, as an ingredient in varnishes, as a chemical discriminant in analysis, as a means of rendering tracing-paper temporarily transparent, etc.; but its most important application is to the manufacture of nitro-benzol.

When a mixture of oil of vitriol and hydric nitrate is carefully

cooled and poured into benzol, water and nitro-benzol are formed. The operation, which is performed in iron or earthenware vessels, has to be aided by continual agitation, and any rise of temperature prevented by an external stream of cold water. As soon as the chemical action has terminated, a large quantity of water is added, when a yellow oil falls to the bottom of the liquid. This is washed with a weak alkaline ley, and distilled if required. The dilute oil of vitriol and hydric nitrate, which form a necessary by-product of this process, are sold to the manufacturer of hydric sulphate (sulphuric acid), by whom they are transferred directly to the "leaden chambers."

Collas, a Parisian pharmaceutist, was the first to prepare nitro-benzol on a commercial scale. Its odour, so remarkably similar to that of bitter almond oil, led him to employ it in perfumery under the name of "Essence de Mirbane." Its peculiar and somewhat obscurely noxious after-effects on the human body decidedly forbid its use as a flavour. But the true value of nitro-benzol lies in its being the source of aniline, from which, in its turn, so many beautiful and well-known colours have been derived. The transformation into aniline is easily and simply effected. From a large number of "reducing processes," as they are termed, all of which are in principle identical, the practical chemistry of commerce has selected one, for which we are indebted to Béchamp. The method consists in placing nitro-benzol in contact with iron filings, and hydric acetate, in a suitable distillatory apparatus, and applying heat, when aniline distils over. The chemical effect of the reagents is to remove the oxygen of the nitro-benzol, and to place hydrogen in its stead. The following formulæ will serve as a sort of historical synopsis of what occurs:

Benzol . . .	$C_6 H_5 (H) = C_6 H_6$.
Nitro-benzol . .	$C_6 H_5 (N O_2)$.
"Amido-benzol," or aniline .	$C_6 H_5 (N H_2)$.

Aniline is a colourless liquid, having a peculiar but not unpleasant smell; it is a little heavier than water, and boils at 182°. It is known to be present, in very minute proportions, in crude tar. Pure aniline, however, is seldom if ever realized as a manufacturing product, a circumstance which will be readily understood from the following considerations. The benzol usually employed as a source of aniline, almost invariably contains more or less toluol, xylol, and other light oily bodies of a nature quite kindred to itself. Like it, they form nitro-compounds and amido-compounds, all of which in their respective chemical functions, are identical. The sale and employ-

ment of commercial nitro-benzols depend on chemical composition, of which an estimate can be made from their boiling-points. These range usually from 205° to 235° and yield from nearly 75½ per cent. (the theoretical quantity) to 55 per cent. of aniline. This aniline is contaminated with amido-totuol, amido-xylol, etc., bodies which, in proportion to the amount in which they are present, materially affect the nature of the colour that may be prepared from it.

Benzol and its congeners are undoubtedly the most important hydrocarbons that exist in coal-tar. They are directly allied to benzoic acid, oil of bitter almonds, and other "aromatic" bodies, in which group they stand as the representatives of marsh-gas in the "fatty" series of substances, of which common alcohol is a member.

Among the various impediments to the efficient delivery of gas to its consumer, a crystalline hydrocarbon has at times been found deposited in the mains, and blocking them up, even at a remote distance from the works. This has been named *naphthalin.* It forms pearly plates of great beauty, and very considerable size, which can be sublimed and carried along by another vapour, even more easily than camphor. Its odour is rather repulsive. When treated with hydric nitrate it undergoes precisely the same transformation as benzol; and the *nitro*-naphthalin thus produced is capable of conversion, like its analogue, into amido-naphthalin, or naphthylamine, a solid basic body, generally very similar to, but much less stable than aniline. Many attempts were made to utilize naphthalin as a source of colour, but without result, until Martius and Griess succeeded, about three years since, in producing from it a beautiful and permanent yellow dye. This was accomplished as follows. To an aqueous solution of the compound of naphthylamine with hydric chloride, potassic nitrite was slowly added, until a small portion of the liquid gave a cherry-red precipitate on treatment with an alkali. Hydric nitrate was then poured into the liquid, the temperature of which was gradually raised to the boiling point. Much nitrogen escaped, and a crystalline deposit collected continuously round the sides of the vessel wherein the operation was performed. The new colour, whose systematic name is dinitronaphthol, is capable of dyeing silk and wool without a mordant, and of any required shade between a bright citron and a deep golden yellow. Its tinctorial power is considerable, a kilogramme of the sodic or calcic salt (the usual form in which it occurs in commerce), being capable of imparting a fine yellow tint to two hundred times its weight of wool.

It deserves to be pointed out that the utilization of naphthalin in this manner could hardly have been effected without the prior inquiries of Griess; who, quite independently of any industrial object, had occupied himself with an important investigation into certain reactions of a derivative of hydric nitrate. When the proper time arrived, it was easy for this chemist and his coadjutor to apply the results of pure research to the solution of an industrial problem. There are many hydrocarbons existing in the "dead oil" of tar, and boiling above 220°, which yet remain unprofitable, except as coarse illuminating agents, but are no doubt also approaching that critical moment when, like two intersecting curves, their preparation in the pure state on a large scale, and some new epoch in chemical theory shall reach the same happy point simultaneously.

Two groups of hydrocarbons which are found in tar may be alluded to very briefly. These are a few fluid "olefines," hexylene and heptylene, for example, which owe their name to the fact that they form oily compounds with chlorine. There are also a few members of the marsh-gas group, such as octylic and decylic hydride, which belong, as has been already stated, to the fatty series of bodies. Neither of these is found in more than a small amount in coal-tar; into which, though their occurrence there is important and interesting, they appear to have intruded as unexpected visitors. They cannot be extracted economically from such an overwhelming amount of foreign ingredients, nor are they in themselves a source of colour. Both they and all their immediate allies, however, admit of easy preparation by other methods, and are already in use, to a greater or less extent, as valuable means of modifying shades of colour which have been obtained by known processes. Their use is, in fact, to borrow a naturalist's term, chiefly for purposes of "crossing." The first conscious step in this direction was made by Hofmann in 1863. Having ascertained by experiment, that aniline blue was triphenyl-rosaniline, in other words, magenta (rosaniline), in which three units of hydrogen had been exchanged for phenyl; he immediately proceeded to try the effect of introducing methyl, ethyl, etc., instead of phenyl, and with very satisfactory results. These will be referred to more fully in a future article.

One of the most important dye-stuffs which is manufactured is madder. Its employment is very ancient, for it is mentioned by Dioscorides as a plant commonly cultivated in his time for tinctorial purposes. The well-known Turkey-red is a madder dye, remarkable for its permanence and stability; and so valuable, that a large

extent of ground in Europe is occupied with the production of the primitive material. But although the art of madder-dyeing is centuries old, it was not until the rise of modern theoretical chemistry that scientific investigations were undertaken into the nature of the process as a whole. The subject proved extremely complicated, and seemed to grow more obscure with the amount of attention that was directed to it, when a happy surmise threw light upon the dim inquiry. It now seems certain that the fresh plant contains no colouring constituent, but that, as soon as the conditions of growth are removed, and common water (not below a certain temperature) is added, one or more substances contained in it undergo decomposition and yield colouring matter with great rapidity. There are other known instances of this kind. Indigo-blue, for example, does not pre-exist in the plant, but is produced by oxidation in presence of water.

The course of experiment soon revealed the existence of two colours in the altered madder, viz., *alizarine* and *purpurine*, the former being, in all probability, the real basis of Turkey-red. These bodies are remarkably similar to each other in their chemical properties; but they can be separated from each other, and obtained in the pure state without much difficulty. They are both crystalline, are taken up by many solvents, and can be sublimed, if due care be exercised. Hence, it appeared at first sight, their chemical formulæ could be determined; and formulæ which very accurately represent the percentage composition of these bodies were undoubtedly attained. But the nature of the case (I now allude to alizarine only) precluded a perfect decision; and chemists, for the most part, accepted the expression of Wolff and Strecker ($C_{10}\,H_6\,O_3$) as, upon the whole, the most probable that could then be devised.

It was at this point—a purely theoretical one, it will be perceived—that the madder manufacture began to feel the influence of coal-tar utilization, an industry which had sprung up meanwhile, with silent but startling rapidity; for chemists had investigated many of the tar products, and, in accordance with their invariable practice, had assigned a formula to each of them. Now it could not fail to be noticed that naphthalin ($C_{10}\,H_8$), at that time a perfectly useless substance, agreed with alizarine in containing the unit of carbon ten times; and as the transformation of H_8 into ($H_6\,O_3$) promised to be accomplished by known methods, it was confidently asserted that the artificial formation of alizarine from naphthalin would be merely a question of time. A suitable derivative of naphthalin was duly

obtained. Chloroxynaphthalic acid, as it was termed ($C_{10}\ H_5\ Cl\ O_3$), can be prepared in any desired quantity from the primitive hydrocarbon; and, if the theory were true, it would only be necessary to remove chlorine (Cl) from the derivative, and put hydrogen (H) in its place, to arrive at artificial alizarine ($C_{10}\ H_6\ O_3$). Investigation showed that, although this exchange could not be effected by any of the ordinary expedients, yet the substance, $C_{10}\ H_6\ O_3$, could be prepared from naphthalin in another, but rather circuitous way. It was not, however, identical with alizarine, and proved to be a yellow instead of a red dye,—belonging, moreover, to quite a different class of tinctorial agents.

Now, there could be no doubt whatever about the correctness of the assumed formula for naphthalin, and little, if any, about that of chloroxynaphthalic acid. Either, therefore, the formula for alizarine was false, or, if not, the difficulty must be solved by isomerism. It is unnecessary to allude more particularly to the effect of adopting the latter alternative, inasmuch as the researches of Graebe and Liebermann have, only within the last two years, convincingly shown that we must accept the former. The formula, then, is not $C_{10}\ H_6\ O_3$, but $C_{14}\ H_8\ O_4$. Now, though both expressions are very accordant so far as representing chemical *composition* is concerned,—

	$C_{10}\ H_6\ O_3$	$C_{14}\ H_8\ O_4$
Carbon	69·0	70·0
Hydrogen	3·4	3·3
Oxygen	27·6	26·7
	100·0	100·0

the chemical *relationships* they suggest are very different indeed. The question then arises, If the C_{10} formula assign alizarine to the wrong hydrocarbon, to what hydrocarbon does the C_{14} formula rightly conduct?

The material for a full answer lay ready to hand. Many years ago, the distinguished Laurent had imperfectly isolated a solid, crystalline, volatile body from parts of the tar which boiled at a very elevated temperature, and made an approximate study of its properties. After a considerable interval, Anderson resumed the inquiry, and with such success as to leave no doubt, in the minds of chemists, that he had acquired for science both the method of preparing a pure substance, its accurate symbolic expression, and the general nature of its chemical deportment. The hydrocarbon,

to which the name of anthracene, C_{14} H_{10} was now given, yielded a numerous progeny of derivatives, among which *oxanthracene* was more especially described by Anderson. Graebe and Liebermann commenced by treating alizarine itself with zinc and water, in such a manner as to completely deoxidize and hydrogenate it. The result of this operation was the formation of *anthracene,* which was consequently the hydrocarbon sought in answer to the question above stated. The relation between alizarine and oxanthracene became immediately apparent, and it was only necessary to act upon the latter alternately with bromine and potash to obtain dioxy-oxanthracene; in other words, alizarine itself. It is now known that alizarine can be prepared from this source in quantity sufficient to meet any commercial requirement.

Professor Stokes, in his opening address to the British Association at Exeter, justly drew attention to this remarkable instance of the nature of many chemical discoveries, which may revolutionize the entire province of a manufacture, and alter the direction or magnitude of most important social forces. The successful preparation of alizarine from coal-tar necessarily involves the gradual abandonment of madder agriculture, and of the production of garancin, the devotion of much land and labour to other useful purposes, and the creation of a new and most important industry. Illustrations of such results abound in chemical history. The colours derived from lichens, dye-woods, cochineal, for instance, are either no longer produced, or on a small scale only, having been displaced by coal-tar dyes. Washing soda, formerly imported from Spain, where it was made from burnt seaweed, is no longer manufactured there, that country purchasing her supplies from the Clyde. Of Sicily, again, we are now independent, our own pyrites furnishing us with abundance of the sulphur, of which she formerly had a monopoly.

With the benzol series, napthalin and anthracene, the list of characteristic tar hydrocarbons at present utilized is exhausted. We cannot doubt, however, that tar will be almost as fertile a field of discovery in the future as it has been in the past, and that commerce will rapidly avail herself of the tardier results of theoretical research.

In a subsequent article, I hope to give some exposition of the history of the *coal-tar colour* manufacture, and of the scientific principles upon which it is founded. A table of the products of the destructive distillation of coal is here appended, as serving to supply an accurate idea of the stage which this branch of chemical

inquiry has hitherto attained. It is based on a similar one compiled by Dr. Hofmann in 1862, to which a few more terms have been added. The boiling-points have been corrected to the present time, and the existence of groups is specially indicated by group names. The evident connection between boiling-point and chemical composition, the step-like progression of formulæ in a group, and other relations of various kinds, render this table in itself a very interesting study.

PRODUCTS OF THE DESTRUCTIVE DISTILLATION OF COAL.

	NAME.	FORMULA.	BOILING POINT, C.
			DEGREES.
FATTY HYDRIDES.	Hydrogen	H_2	—
	Methylic hydride (marsh-gas)	$C\ H_4$	—
	Amylic hydride	$C_5\ H_{12}$	40
	Hexylic hydride	$C_6\ H_{14}$	69
	Octylic hydride	$C_8\ H_{18}$	119
	Decylic hydride	$C_{10}\ H_{22}$	157
	Paraffin	$C_n\ H_{2n+2}$	—
OLEFINES.	Ethylene	$C_2\ H_4$	—
	Tetrylene	$C_4\ H_8$	3
	Hexylene	$C_6\ H_{12}$	55
	Heptylene	$C_7\ H_{14}$	95
	Acetylene	$C_2\ H_2$	—
AROMATIC HYDRIDES.	Benzol	$C_6\ H_6$	82
	Parabenzol	$C_6\ H_6$	97·5
	Toluol	$C_7\ H_8$	111
	Xylol	$C_8\ H_{10}$	139
	Cumol	$C_9\ H_{12}$	166
	Cymol	$C_{10}\ H_{14}$	177
	Styrolene	$C_8\ H_8$	146
	Naphthalin	$C_{10}\ H_8$	212
	Acenapthene	$C_{12}\ H_{10}$	285
	Chrysene	$C_{18}\ H_{12}$	350
	Anthracene	$C_{14}\ H_{10}$	360
	Retene	$C_{18}\ H_{18}$	400 (?)
	Water	$H_2\ O$	100
PHENOLS.	Phenol	$C_6\ H_6\ O$	188
	Cresol	$C_7\ H_8\ O$	203
	Phlorol	$C_8\ H_{10}\ O$	—
	Hydric sulphide	$H_2\ S$	—
	Hydric cyanide	$H\ C\ N$	26·5
	Hydric sulpho-cyanide	$H\ C\ N\ S$	—
	Carbonic oxide	$C\ O$	—
	Carbonic dioxide	$C\ O_2$	—
	Carbonic disulphide	$C\ S_2$	47
	Sulphuric dioxide	$S\ O_2$	—10
	Hydric acetate	$H\ C_2\ H_3\ O_2$	120

	NAME.	FORMULA.	BOILING, POINT, C.
			DEGREES.
	Ammonia	$H_3 N$	—33
	Aniline	$C_6 H_7 N$	182
	Cespitine	$C_5 H_{13} N$	96
PYRIDINE SERIES.	Pyridine	$C_5 H_5 N$	115
PYRIDINE SERIES.	Picoline	$C_6 H_7 N$	134
PYRIDINE SERIES.	Lutidine	$C_7 H_9 N$	154
PYRIDINE SERIES.	Collidine	$C_8 H_{11} N$	170
PYRIDINE SERIES.	Parvoline	$C_9 H_{13} N$	188
PYRIDINE SERIES.	Coridine	$C_{10} H_{15} N$	211
PYRIDINE SERIES.	Rubidine	$C_{11} H_{17} N$	230
PYRIDINE SERIES.	Viridine	$C_{12} H_{19} N$	251
LEUCOLINE SERIES.	Leucoline	$C_9 H_7 N$	235
LEUCOLINE SERIES.	Lepidine	$C_{10} H_9 N$	260
LEUCOLINE SERIES.	Cryptidine	$C_{11} H_{11} N$	—
	Pyrrhol	$C_4 H_5 N$	133

THE ASS AND HORSE OF ARYAN ANTIQUITY.

M. F. LENORMONT read a paper on this subject to the French Academy, in February, in which he says: "The horse is one of the domestic animals which the Aryans possessed most anciently, and the use of which was general amongst their tribes before they were divided, to spread, some in Europe, and others in Persia and India. The name of the horse is, in fact, the same in all the Aryan idioms. In Sanscrit it is *açva;* in Zend, *açpa;* in Persian, *asp;* in Armenian, *asb;* in Lithuanian, *aszwà;* in Latin, *equus;* in Greek, ἵππος, derived from a primitive ἴχϝος and ἴχχϝος, which was only preserved amongst the Eolians; in Gaulish, *epos;* Gothic, *aihvus;* old German, *ehu.* This name usually signifies 'the rapid animal.' Moreover, the horse was used exclusively by the primitive Aryans as an animal for drawing, attached to chariots. In the Vedas, equitation is still unknown; and among the Hellenic populations, the origin of this art is placed in Thessaly, and the fable of the Centaurs refers to it.

"The ass, on the contrary, was neither known to, nor employed by, the Aryans in their primitive country, or before their separation, for it has no common name amongst the divers peoples descended from them. Its Sanscrit names are mostly Indian; one only is found in the Iranian languages; and this name, *khara,* is shown by M. Pictet not to be of Aryan origin, but directly bor-

rowed from a Semitic source: Hebrew, *'air;* Arabic, *ʿayr.* This shows the way by which the Iranians first, and then the Indians, received the domestic ass. In Celtic, Germanic, and Sclavonian languages, the names of the ass, according to the ingenious remark of Diefenbach, belong to two types, which are manifestly derived from the two Latin forms, *asinus* and *asellus.* The derivations of *asinus* are: Cymric, *asyn;* Cornish, *asen;* Armorican, *azen;* Anglo-Saxon, *assene;* Scandinavian, *asni;* Danish, *asen.* Those of *asellus:* Gothic, *asilus;* Anglo-Saxon, *asal, esol;* old German, *esil;* Sclavonic, *osilia;* Russian, *oseli;* Polish, *osiel;* Illyrian, *osal;* Lithuanian, *asilas;* Erse, *asail, asal.*

"The Greek name of this animal has been made the subject of special study by M. Benfey. This eminent philologist has proved that it passed through three successive forms, *ὄτνος, ὄσνος,* and *ὄνος.* From the second comes the Latin *asinus.* As for the primitive form, *ὄτνος,* M. Benfey has established its Semitic origin, and that it comes from one of the names used in this family of languages: the Hebrew, *âtôn,* plural *atnôt;* the Aramean, *atânâ;* the Arabic, *atan,* plural *utn.* This name is derived from the root, *atana,* to walk slowly, and is perfectly applicable to the phlegmatic movements of the ass.

"It is easy to draw conclusions from these linguistic facts: that the horse was employed by the Aryans as a domestic animal in the most remote periods to which we can trace their history, before their separation into western and eastern tribes—that is to say, in a period before they penetrated into Egypt. The ass, on the contrary, was, at the same period, totally unknown to the Aryans, and the divers Aryan nations in Europe and Asia only received it separately at a much later time, and in the countries to which they conducted their great emigration.

"This animal was communicated to the Iranians of Persia by the Semitic people of Mesopotamia, and from them it passed into India, always keeping its Semitic name, a certain indication of its origin. Among the Greeks, the ass was introduced by peoples speaking a Semitic language—probably the Phenicians—and it was completely naturalized among them when the Homeric poems were composed. The Latins received it from the Greeks, and, in their turn, spread it amongst the peoples of northern and western Europe, the Celts of the continent, the inhabitants of Britany, the Germans, Scandinavians, and even the Sclaves. In the time of Aristotle, even, there were no asses, neither in Scythia nor the neighbouring countries, nor even in Gaul.

"These facts revealed by philology, joined to that we have learnt from the monumental representations of ancient Egypt, and from Bible texts, go to prove that the horse and the ass originated in completely opposite countries. The horse was reduced to the domestic state on the plateaux of Central Asia, and the Aryan emigrations were the most powerful means of diffusing it over the world. The Semitic races were last in adopting it, and it did not appear in Egypt till about 2500 years before the Christian era. The ass is an African species, which must have been first domesticated on the banks of the Nile; and from Egypt it soon passed amongst the Semitic races, who, at a later date, transmitted it to the Aryan tribes in Greece, on one side, and Persia on the other. Thus, this animal, in its diffusion, which ended in becoming universal, has followed a course precisely opposite to that of the horse, and, starting from opposite points, the horse and the ass have become united everywhere in simultaneous usage."

GREAT SNOW FALL AMONGST OLIVES AND PALMS.

M. C. Naudin in a letter to M. Ch. St. Claire-Deville, which was lately read before the French Academy, describes a remarkable fall of snow which occurred on the 17th January at Collioure, on the borders of the Mediterranean, lat. 42° 32′, in the department of the Western Pyrenees.

It appears that after a pretty long series of fine days, during which the maximum temperature had varied from 11° to 17° C. (or from 51·8° to 62·6° F.) it grew gradually colder. On the 17th January the maximum between one and two in the afternoon was still 14·5°; and on the 18th it fell to 8·2°, on the 19th to 6°, and on the 20th to 4·5°, the minimum being zero of the centigrade scale, or the freezing point of Fahrenheit's at seven A.M. The air was very calm and the sky very cloudy. On the 21st January, about five A.M., the temperature of the air being —0·8°, snow began falling in fine thick flakes, a sharp north wind whirling them in all directions. This continued all day without a minute's relapse, and all the night between the 21st and 22nd, and also some time on the 23rd; lasting without interruption at least forty-four hours. During this storm the thermometer scarcely moved from the freezing point more than a few tenths of a degree either way.

On the 23rd the sky became clear again, and the wind having

turned from the north to the north-west the temperature rose a little; at seven the thermometer indicated +1°, at noon +4°.* At five P.M. it was at zero, and towards eight P.M. it rose to +2·2°, the varieties corresponding with the state of the sky as it was more or less covered with cloud.

The quantity of snow which fell in this storm at Collioure and its environs during forty-eight hours greatly exceeded anything remembered by middle aged men; but some old men recollected that in 1804, or 1805, for their dates varied, a similar snow storm had occurred. As may be conceived in a district so situated as this part of Roussillon the thickness of the snow fall was far from uniform; but everywhere it was enormous. Near M. Ch. Naudin's house it was from 0·94m. to 0·96m., or about a yard thick.† By a low wall in his garden it was about a yard and a half thick, and in many parts of the valley of Collioure from one and a half to two yards; and the average depth over the whole district was estimated at about thirty-one or thirty-two inches (0·80m.).

M. Naudin remarks that such a snow fall is always disastrous in countries in which the local industry is dependent on trees, and especially on the Mediterranean, where the chief resources are derived from the olive, which is more exposed to injury than ordinary fruit trees, on account of the persistence of its leaves which are broken by the weight of the snow.

The storm of January 17 inflicted inconceivable damage; M. Naudin's olives, for example, being reduced to a confused mass of broken trunks and torn branches, so that out of a hundred scarcely one remained uninjured. The least maltreated were bent like weeping willows, with their heads buried in the snow. The orange and citron trees, notwithstanding the rigidity of their branches, were similarly mutilated, though in a less degree. The deciduous trees suffered less, but great branches of elms and planes were snapped off with the accumulating weight.

M. Naudin was astonished at the way in which the palms endured this storm. They were literally flattened by the weight of the snow, like plants dried in a herbarium, their leaves were spread out in rosettes, and they were imprisoned in the frozen snow; some passing ten, and others eleven and twelve days in the condition, but excepting those in which the heart was broken, they all recovered completely, and when he wrote they had regained

* The + degrees are degrees *above* freezing. The centigrade degrees range from 0° freezing, to 100° boiling.

† The metre is 3 feet 3·371 inches.

their upright position. He observes that geologists who have inferred the existence of a tropical climate in Europe, from the presence of palms amongst miocene fossils, may have less justification than they suppose.

This great snow fall came after six years of remarkable dryness in that part of Frence. M. Martins has called the attention of meteorologists to the concomittance of this dryness with the prevalence of north and north-west winds along the borders of the Mediterranean, and M. Naudin thinks this condition of the atmosphere may be connected with the great snow fall.

It was also observed by M. Martins, that the cause of the death of plants in the winter are more complicated than are generally supposed, and that we must give up the notion of defining the exact temperature below which they must perish.

M. Naudin is engaged in a series of experiments to determine the conditions under which plants are able to resist climatic vicissitudes.

FOREIGN SCIENCE.

Radiation.—The well-known observation of Leslie, that rough surfaces emit more heat than smooth ones, has been hitherto universally explained by supposing an alteration of density to have been brought about in the process of roughening. Magnus has recently investigated this question, and his results lead him to doubt the prevalent theory. He has found, for example, that a platinum plate, when made as hard as possible by rolling, undergoes no loss of radiating power after it has been heated to whiteness, and is consequently much softer. Platinum that has been softened, and rubbed with emery paper, radiates twice as much heat as before; and, if covered with very finely divided platinum (by ignition of ammonia-platinic chloride upon its surface), the radiation is increased seven-fold. It is clear then, that the altered density of the surface—if, indeed, any such change has occurred—has no connection with radiating power, which is, on the contrary, much affected by the *extent* of surface exposed as a result of fine division. The phenomenon is no doubt ultimately due to the refraction which a ray of heat suffers at the boundary of a radiant body. When the refraction is great and the surface smooth, most of the heat undergoes total internal reflection. The values of the coefficients of

refraction for metals are considerable, whence their radiating power is necessarily small, just as on the other hand, their reflecting power is great for rays incident externally. The increased emission from a roughened surface, is an obvious consequence of these considerations.

PLANT GROWTH.—Wolff has been engaged in studying the influence of different saline solutions of known strength, on the growth of oats. The composition of the ash varied but very slightly with the concentration of the solution, nor was the health of the plant at all affected thereby; whence it appears that it is unnecessary to concentrate the applied liquid further than a certain point, which, in this case, is reached when it contains 0·1 per cent. of dissolved material. Complete displacement of lime by potash or magnesia, was attended with arrest of vegetative power, after the second or third leaf had appeared; increase of the per centage of lime beyond a certain limit was also found to be prejudicial. Potash was readily absorbed by the roots, but soda only slightly; the latter being found afterwards principally in the stem, while the grain contained scarcely any. Lime exists in the dried oat plant to the extent of about 0·3 per cent.; and it was found that a smaller supply than this was followed by injurious results. When $\frac{7}{8}$ths of the potash in the nutritive solution was displaced by lime, absorption became difficult, and the per centage of ash was diminished.

INFLUENCE OF COLD ON MINUTE ORGANISMS.—Schenk has communicated to the Academy of Vienna some interesting observations on the influence of a temperature of —3° C. to —7° C. on vital functions. White blood corpuscles, if exposed for a short time to such conditions, do not lose their usual irritability at a higher temperature, nor does a longer exposure below —7° altogether destroy it. Impregnated batrachian ova, which had been submitted to a cold of —3° for an hour, were very successfully developed after thawing; at —7°, however, life appeared to have become extinct. Ripe, unfertilized ova admitted of fertilization after exposure to —4° for an hour; but spermatozoa, placed in the same circumstances, did not fertilize ripe ova after thawing, though still exhibiting their normal movements. Schenk infers from this last experiment that these spermatozoic movements are not in any way connected with impregnation.

ARTIFICIAL INDIGO.—Some very promising researches have been made upon this subject by Baeyer and Emmerling. It is well known that indigo (C_8H_5NO) is converted by oxidizing agents into isatin, from which, by successive processes of reduction, *indol*

(C_8H_7N) is formed, this being in reality the parent substance to which indigo and its derivatives must be referred. Now the chemists just named have succeeded in preparing indol from cuinamic acid, which, when nitrated, furnishes nitro-cuinamic acid—a body only differing from indol by containing carbonic oxide and oxygen ($C_8H_7N + CO_2 + O_2$); these last are easily removed by a mixture of potash with iron filings, and indol is formed, in every respect identical with the product obtained from indigo.

The remaining point of the problem has yet to be solved. It will now be necessary to retrace our steps from indol back to indigo; a task which will probably be completed at an early date. We shall thus be possessed of an unbroken chain of transformations from benzol to indigo, which will then have to be enrolled in the catalogue of coal-tar colours, and added to the long list of the triumphs of organic chemistry.

LITERARY NOTICES.

Homer. The Odyssey. By the Rev. W. Lucas Collins, M.A., author of "Etonia," "The Public Schools," etc. (Blackwood and Sons.)—Mr. Collins has a remarkable talent for the work he has undertaken, and we may congratulate him on having placed the Odyssey in as able and interesting a way before general readers as he had done previously with the Iliad. A mere translation of poems of this description, however excellent, would not accomplish what Mr. Collins has achieved by his method of telling the story with appropriate comments, and only resorting to actual translation when some peculiar beauty is to be exhibited, or some special characteristic displayed. If we were to compare what Mr. Collins has done with other performances, we should say that his Iliad and Odyssey were like very clever lectures on the two poems, supplying at each point exactly what is wanted to enable persons of ordinary education to follow and appreciate the narration of the bard. We could not name any two books of pleasant reading from which a greater variety of information on old Greek modes of thought and early civilization could be obtained than from the Iliad and Odyssey of this series. The great fame of the former poem has too often tended to eclipse the merits of the latter, which in many respects, such as variety of incident, more skilful plot, and wider range of observation, decidedly surpasses it. Mr. Collins has

pointed out the strong and interesting resemblances between the delineations of the Odyssey and those of the old Hebrew writers, in whose pages patriarchs, warriors, kings, princesses, shepherds, etc., display the same characteristics and very similar modes of thought; nor has he failed to notice how the spirit of Arthurian legends and the tales of chivalry and enchantment were prefigured by the ancient Greek. In similar stages of society, whatever may be their chronological date, man appears pretty much the same, wherever may be the scene of his labours, or whatever may be the precise forms of his belief. A short quotation will illustrate some of these facts:—"The Homeric kings," says Mr. Collins, "like those of Israel and Judah, lead the battle in their chariots. Priam sits in the gate, like David or Solomon; Ulysses, when he would assert his royalty, stands by a pillar, as stood Joash and Josiah. Their riches consist chiefly in sheep and oxen, men servants and maid servants. When Ulysses, in the Iliad, finds Diomed sleeping outside his tent, and his comrades lay sleeping around him, and under their heads they had their shields, and their spears were fixed in the ground by the butt-end—we have the picture, almost word for word, of Saul's night bivouac, when he was surprised by David. 'And behold Saul lay sleeping within the trench, and his spear stuck in the ground at his bolster, and the people lay round about him.' Ulysses and Diomed think it not beneath their dignity as kings, or chiefs, to act what we should consider the part of a spy, like Gideon, in the camp of the Midianites; Lycurgus, the Thracian, slays with an ox goad, like Shamgar, in the 'Book of Judges.' The very cruelties of warfare are the same—the insults too frequently offered to the dead body of an enemy; the children dashed against the stones; the miserable sight which Priam foresees in the fall of his city, as Isaiah in the prophetic burden of Babylon."

Chemistry for Schools: An Introduction to the Practical Study of Chemistry. By C. Houghton Gill, Assistant Examiner in Chemistry at the University of London, late Teacher of Chemistry and Experimental Physics in University College School, with 100 Illustrations. (Walton.)—This is the best book of its sort that has appeared since the recent extension of chemical knowledge, and the acceptance of new theoretical views has called forth a fresh series of manuals. It takes quite different ground from the admirable work of Mr. Barff, the "Introduction to Scientific Chemistry," which deals systematically and more philosophically with the non-metallic elements only, while Mr. Gill includes several of the metals, and has in view to

supply "a sufficient manual of chemistry for schools and junior students." He has displayed considerable skill in arranging his matter so as to lead from facts to reasoning, and gradually familiarise his pupils with the chief outlines of chemical theory as it now stands, simple and probable in some particulars, and obviously defective and irrational in others. It is only fair to Mr. Gill to say that he, for the most part, makes the best of difficulties yet unsolved, though he attaches more importance than it deserves to the line of argument by which Professor Williamson endeavours to prolong the existence of the hypothetical "atom," in which the immediate followers of Dalton attempted to find rest. Each chapter of Mr. Gill's book ends with a useful set of questions, and his line of teaching coincides with that employed in the classes at University College, which is probably the best and most successful now in use.

Our Domestic Fire Places. A New Edition, entirely Re-written and enlarged, the additions completing the Author's contributions on the Domestic Use of Fuel, and on Ventilation. By Frederick Edwards, jun. (Longmans.)—We are glad to find this useful work re-issued with such alterations and additions as the author's further experience and the progress of invention has rendered advisable. Mr. Edwards's essay occupies an intermediate position between a strictly scientific and an ordinary popular treatise, and its subject matter certainly concerns all who occupy houses, or have to purchase stoves. The book is illustrated with numerous plates, containing 149 figures of various forms of stoves and heating apparatus, ancient and modern, and great disappointment and annoyance might be avoided by spending a few hours in its careful perusal. It is very common to find grates, even in good houses, of the most abominable construction, and few occupations are more miserable and hopeless than that of trying to make them give out a reasonable quantity of heat, on such bitter days as last February made us acquainted with. The following passage will show some of the conclusions to which Mr. Edwards has arrived:—"With respect to the general form of grate, that appears to be unquestionably best which presents the largest amount of radiating or reflecting surface to the room. Upon this point the old fashioned grates were entirely deficient." Mr. Edwards appears to give a preference to King's patent, the popular objection to which would be on account of its square outlines, which he considers "better adapted than the semi-circular, to the outlines of rooms and chimney pieces." The figure given of King's grate shows that it has unusually large reflecting and radiating surfaces;

the smoke makes its exit at the back, through a door suspended, so that the extent of its opening can be readily adjusted with a poker. We do not, however, agree with the writer that there is any artistic "incongruity in placing semi-circular forms, with blank corners, within a square space." Circles inscribed in squares cannot be condemned as erroneous combinations, and most eyes are pleased where straight lines contrast with suitable curves. The use of fire-brick and "fire-lump" backs for stoves, and the avoidance of masses of iron, which tend to conduct the heat where it is of no use, are forcibly pointed out in this work, and air channels, near the grate, communicating with an external supply, are strongly recommended. Mr. Edwards does not seem at all hopeless of final success in the contrivance of smoke-consuming grates, which shall be free from the objections practically found in those hitherto constructed; but he looks upon the British public as a slow pupil, and is not sanguine enough to expect a speedy abandonment of time honoured mistakes.

A TREATISE ON MEDICAL ELECTRICITY, THEORETICAL AND PRACTICAL; and its use in the Treatment of Paralysis, Neuralgia, and other Diseases. By Julius Althaus, M.D., Member of the Royal College of Physicians, Fellow of the Royal Medical and Chirurgical Society, Physician to the Infirmary for Epilepsy and Paralysis. Second Edition. Revised and partly rewritten. (Longmans).—In spite of its defects, this is the most important English work on the subject of Medical Electricity, which as yet has been very far from receiving the attention it deserves. When the powers of electricity were first known, great hopes were entertained that it would be of much use in the cure of many forms of disease; but, though some experiments were successful, others failed to do good, or even did harm, and the question languished a good deal for want of adequate scientific knowledge and skill being brought to bear upon it. The first chapter of Dr. Althaus' book opens with passages tending to prejudice any scientific reader against it, and much of it would be improved in correctness by flat negative. Thus, Dr. Althaus says, "It is generally admitted that all bodies contain a very subtle fluid called natural electricity, which is composed of two contrary fluids, termed positive and negative electricity." This, with more of the same sort, would be all the better for putting the word *not* before "generally admitted," as no one really believes anything of the kind, or accepts the two-fluid theory as having any correspondence with actual fact. His explanation that friction, etc., "calls an electro-motive force into existence which separates the two fluids

formerly united," is simple bosh; and when he comes to, "we now know that amber when rubbed acquires the property of attracting light bodies, merely because by friction the natural electricity of amber is decomposed, and negative or resinous electricity is accumulated in the state of rest upon the rubbed body," we cannot but wonder how any man within a thousand miles of the modern scientific world can put his name to such rubbish. No "*we*" in existence possess the *knowledge* thus asserted, and there is not the slightest reason for supposing the explanation to be correct. Dr. Althaus does not seem to understand the fundamental distinction between statical and dynamical forces. The electric forces—whatever they may be—are statical, and balance each other in the amber—if they exist there at all—before the friction is applied, and when they are excited and active in attracting other bodies, Dr. Althaus speaks of them as at "rest." We notice also that he calls frictional electricity "statical electricity," as if it were not quite as capable of dynamic exhibition as any other form. It is when he comes to describe the various modes of applying electricity obtained from different sources, that his work promises to be useful, and he adduces a large quantity of important and interesting matter, which we commend to the attention of our professional and other readers. The range of disorders in which electricity has been found useful is very much greater than might be expected, and includes even excessive drinking persisted in to relieve the deplorable consequences of failure of nervous power. The surgical applications of electricity are extremely interesting, and it appears not only to be valuable for removing tumours by the actual cautery of white hot wires, but in a milder form to have the power of causing the absorption of certain kinds.

Dr. Althaus' book affords considerable information about apparatus and instruments, but he does not seem to be acquainted with the remarkably portable and powerful magneto-induction apparatus devised by Mr. Browning—decidedly the best of its kind.

MEMOIRS READ BEFORE THE ANTHROPOLOGICAL SOCIETY OF LONDON, 1867-8-9. Vol. III. (Longmans.)—Many of these papers possess considerable interest, as, for example, one by Lieut. Oliver on the Hovas, and other Tribes of Madagascar. The Vuzimba, or Kimos of this island have a ceremony like the Jewish Passover, when cattle are slain, blood sprinkled on the doorposts, and a hasty meal eaten. They have likewise rites of purification, ordeal by bitter waters, wave offerings, and other practices resembling those of the ancient Jews. Dr. J. B. Davis describes the skeleton of Aino

woman an aboriginal of the Japanese island Yesso; Dr. Gibb discourses on the Pendency of the Epiglottis; Babu Rajendrala'la gives a very interesting account of the Gipsies of Bengal; Dr. Short treats of the Bayaderes, adducing new facts; Mr. Bollaert contributes to the elucidation of the very difficult question of American hieroglyphs, at which he has so long worked; Dr. Beddoe makes an elaborate inquiry into the Stature and Bulk of Man in the British Isles, and several other writers treat of subjects more or less important. Dr. Beddoe's paper well deserves serious attention, and if he has not been able to complete his researches, he has collected much valuable information, and laid a good foundation for further work. He confirms the prevalent belief of the tendency of many branches of manufacture to dwarf and lower the physical characters of our population. The average height of adult Englishmen he places between 5ft. 6in. and 5ft. 7in. Lunatics and hereditary criminals fall below the average, and among the lunatics who are tall, the majority seem to be dark-haired, and disposed to melancholy madness. Dr. Beddoe finds the Scandinavian type tending to prevail amongst the aristocracy, and the Saxon amongst the trading class. The difficulties of collecting information concerning the stature and weight of different classes varied much with the localities, and in themselves form an instructive element in the information obtained. In the eastern counties many promises of help failed, and in the west it was not at all easy to get the folks to interest themselves in the inquiry. In the south-east the peasantry are reported as "very shy," probably from some superstitious motive. The south-west counties were more manageable, and cultivators of natural science are reported by Mr. Macintosh to be much more numerous in the west than in the east. In Wales the people were afraid that the Government wanted the information for some bad purpose. In parts of Yorkshire, "the rugged rudeness of the people, miscalled by themselves independence," often stood in the way. "In Lancashire the jealousy or indifference of employers, and the rudeness and ignorance of workmen have," says Dr. Beddoe, "made my endeavours comparatively fruitless. But the bucolic and Bœotian county of Hereford is the only one from which I have failed to elicit any return whatever."

The Year-Book of Facts in Science and Art. Being the most Important Discoveries and Improvements of the Past Year in Mechanics and the Useful Arts, Natural Philosophy, Electricity, Chemistry, Zoology and Botany, Geology and Mineralogy, Meteorology and Astronomy. By John Timbs, Author of "Curiosities of

Science," "Things not Generally Known," etc. (Lockwood and Co.)—This well-known work continues its accustomed career, bringing to a focus an immense amount of information scattered through a variety of papers and publications. The volume for 1870 is fully equal to its predecessors, and will, no doubt, be as widely appreciated. "The Year Book of Facts" enables a large number of persons who can have no access to original information to follow the leading discoveries of the time.

INTRODUCTORY TEXT-BOOK OF PHYSICAL GEOGRAPHY. By David Page, LL.D., F.R.S.E., F.G.S. Fourth Edition. (W. Blackwood and Sons.)—We are glad to find so excellent a work as Dr. Page's "Introductory Text-Book of Physical Geography" in its Fourth Edition. It is an admirable book for private students and schools.

THE SPHERICAL FORM OF THE EARTH. A Reply to "Parallax." In Letters to a Friend. By J. Dyer. Author of "Thoughts on the Laws of Health."—Mr. Dyer has taken the trouble to reply to the fallacies propounded by a person named "Parallax," who lectures about the country to show that the earth is not a sphere, etc., etc. It is perhaps well that a cheap publication should be in the hands of those who may wish to check nonsensical mystification of an astronomical subject; but we suspect the best way of dealing with "Parallax" is to take no notice of him. Mr. Dyer's work will, however, be useful as a popular and clear view of the subject.

CORRESPONDENCE.

GAS-COKE *v.* OVEN-COKE.

"In the manufacture of coke," says Dr. E. Mills,* "the whole of the volatile products are generally permitted to escape—an instance of negligence and bad economy which deserves the severest reprehension."

Now, the writer does not appear to draw just conclusions from the practical difference between coke resulting from *gas* making and that produced by *coke* making. Coke made in a close retort, for the purpose of economizing the volatile product, is specifically light. Coke made in the oven, with free access to the air, is relatively heavy. Independent, however, of numerous qualities which makes them different, there is this great and important one, namely, that it is found impossible to get the amount of heat in a furnace with gas-coke compared with oven-coke; hence all those manufacturers who make steel tyres, rails, axles, slide rods,

* *Vide* STUDENT for February, p. 70.

armour plates, etc., buy the dear oven-coke in preference to the cheap gas-coke. They pay the difference for the loss of the volatile matter, and the farmer reaps the benefit for nothing when it next rains.

I conclude, therefore, that as this oven-coke is an absolute necessity to our iron workers, it does not deserve "the severest reprehension" cast upon it. SEPTIMUS PIESSE, Ph. D., F.C.S.

[We have inserted Dr. Piesse's note because it shows how easily able men can delude themselves in favour of any established practice. He does not seem to know that the utilization of volatile products wasted in the ordinary processes of coke-burning has long been recognized as a desideratum, and that various plans for that purpose have been devised. A reference to Dr. Percy's "Metallurgy," vol. i., may illuminate him on this subject. The notion of making coke with "free access of air" is quite erroneous, as the coal would, of course, burn to ashes under such circumstances. The assertion that the farmer gets the benefit of a wasteful process for "nothing" is a strange fallacy. In the case of such an article as coke, the price is largely dependent upon the cost of production, and waste is an element of cost.—ED.]

PROGRESS OF INVENTION.

MANUFACTURE OF BENZOLE.—Mr. John Bowley of Well Street, Camberwell, manufactures benzole, by treating the creosote or naphthaline by the distillation of coal tar with chlorine gas, till it is fully saturated; this in conjunction with coal tar naphtha is distilled, and benzole obtained, as well as other homologous products, from which aniline for dyes can be made by the usual methods.

WATERPROOF FACING FOR BRICK BUILDINGS.—This invention is intended to prevent the brickwork of houses absorbing moisture, and is to be used instead of slates or compo. It consists in moulding terra cotta, stoneware, or other plastic waterproof material, into slabs of convenient size and shape, and working these slabs in with the brickwork somewhat after the manner of working facing bricks. One slab is made of such a shape, that its edge when placed on that of another, shall rest against a projecting piece flush with the back of the slabs when superposed; by these means, any water that might accidentally enter at the joints of the slabs, is prevented from entering the brickwork. If desired the slabs may be glazed.

MATCHETS AND CUTLASSES.—Mr. Frederick Major Mole thus des- describes his improved method of manufacturing and pointing

cutlasses. Where the end of the piece of steel is required to be widened or expanded, and its back thinned, I employ a process of cross rolling, that is to say, I use a pair of plain rollers, and pass the heated end of the blank piece of steel to be operated upon between these rollers at their ends; the greatest length of the piece of steel being kept parallel to, or at a small angle with the axes of the rollers during the rolling process, the steel is widened by the pressure of the rollers, and the thickness of the back reduced, and the cutlass is thereby pointed or partially pointed. The pressure of the rollers also rolls out the furrows which are ordinarily made along the strips of steel from which matchets are made. Where those kinds of matchets and cutlasses are to be made, which require one end of the blank to be thinned without widening, or by slightly widening, the end, I effect the thinning of the end by a process of back rolling, that is to say, I use a pair of plain rollers from the surface of one of which a portion has been cut away. These rolls have a continuous rotatory motion. The objects attained by this invention, are economy and a better quality of steel, as it is less injured by this process than by hammering.

DESULPHURIZING COAL.—This method consists in first washing the coal, and then, whether crushed or not, it is subjected to heat in a closed chamber or retort, and chlorine gas is passed in, which will combine with the sulphur compounds evolved from the coal by the heat to which it is subjected. When treating coal to produce coke for metallurgical purposes, chlorine gas is admitted, which penetrates the mass and combines with, and carries off the sulphur. When the coal is to be used for domestic purposes, it is heated with chloride of manganese, or chlorine in closed chambers, but without driving off the inflammable constituents of the coal.

APPARATUS FOR ABSTRACTING HEAT.—To effect this purpose, an apparatus is arranged for working with two separate quantities of air, there are two cylinders parallel and near to each other, and having their ends connected by passages, in which *regenerator* appliances are fixed. Each cylinder has a piston working in it, and one quantity of air is worked at the front ends of the cylinders and the other at the back ends. The ends of one cylinder constitute the *hot* compartments, and in them provision is made for abstracting the heat developed in the air by compression, whilst the ends of the other cylinders constitute the *cold* compartments, provision being made in them for the expanding air to abstract heat from the substance to be cooled. The pistons are actuated by revolving

cranks, disposed at about 135 degrees of the circle from each other, or in an equivalent manner, and the effect of this disposition is, that whilst one piston is approaching one end of its cylinder, the other is moving away from the corresponding end of its cylinder, at nearly the same rate for a considerable part of the stroke, so that the air is transferred from one cylinder to the other with little alteration of its volume. The compressions and expansions are effected at other periods of the piston's strokes when they are not moving at the same rate. Revolving cranks are the most convenient, direct, and simple appliances for actuating the pistons, but levers, cams, or toothed wheels may be, if preferred, used for that purpose. An apparatus may be arranged for the expanding air to abstract heat from the substance to be cooled, through thin separating shells or partitions; or it may be arranged, when employed to cool a liquid, for such liquid to be injected amongst the expanding air, and it may also be arranged for the liquid which abstracts heat from the compressed air, to do so through thin partitions; or the liquid can be injected amongst the compressed air. Any gas not liquifiable at the pressures employed, may be substituted for air. The inventor of this ingenious apparatus is Mr. Alexander Carnegie Kirk, of Glasgow.

TREATING AMMONIACAL GAS LIQUOR.—The liquor is raised by injected steam to 212° Fah. Hydrated oxide of iron, sulphate of iron, or lime are added. The ammoniacal gas passes off, and is arrested by the purifying substances used. If lime only is employed in the boiling, the liquor is purified by the addition of sulphate of iron, until no further precipitate is thrown down. The precipitate formed is available for a pigment; from two to twenty pounds of sulphate of iron may be required for twenty gallons of the liquor, according to its strength. The ammonia arising from the liquor is taken up by dilute sulphuric acid mixed with sawdust, spent tan, or shoddy. The iron is used for the purpose of removing the sulphuretted hydrogen.

APPLYING ELECTRICITY FOR OPENING AND CLOSING GATES OR DOORS, AND FOR ACTUATING SIGNALS.—By this arrangement an electro-magnet, by the passing of an electric current, is made to release mechanism, acted upon by a weight or spring, and thus to allow it to set in motion a gate, door, or signal. A chain is passed round a drum, at one end of which a weight is attached. The drum is connected by spur gearing to a shaft having a crank, connected by a rod to the gate or signal, so that its partial rotatory motion will open or close the gate, or act on the signal. The spur wheel upon

this shaft, which receives the requisite motion from the drum, is not fixed upon the shaft, but causes it to revolve with it only in one direction, by means of a ratchet wheel attached to the spur wheel, in gear with which is a paul carried by an arm of the shaft. The shaft carries a second arm held by a catch, connected by a link to a lever, the free end of which fits into a notch or another lever, on the same shaft with which is an arm, held by the armature of an electro magnet in such manner that by passing an electric current the armature is removed, and the arm is released, and so the first mentioned catch releases its hold of the arm on the crank shaft, and this, obeying the impulse imparted to it by the weighted drum, effects the movement of the gate or signal. In gear with the spur wheel on the drum, is a pinion, which being turned by a winch handle rotates the drum, and so the rope or chain which has run down can be again wound up.

MISCELLANEOUS NOTES.

The Lightning's Autograph.—Under this title we published in The Student, vol. iv., p. 369, an account of an elm-tree struck by lightning at Hanger Hill House, Acton. A further examination of the tree has been recently made by the gardener, Mr. Johnston, and some new facts have been ascertained. Our engraving exhibited the remarkable zigzag groove cut by the electric discharge, and it now appears that above the highest point shown in our sketch, and about thirty feet from the ground, the lightning made a long narrow straight groove, and then any visible mark ceased for about four feet, when it grooved the tree again, as shown in the plate. It is not clear what became of the lightning in the four feet interval between the upper and lower groove. Either it passed outside on the wet and dripping bark, or found the inner masses so excellent a conductor that no disploding action occurred, and no bark was displaced.

Comets and Meteors. — Professor Kirkwood, of Indiana, read an important paper on these bodies before the American Philosophical Society, last November. He finds the orbits of periodical comets to agree with the supposition, that as our Sun and planets move through space they encounter irregularly-distributed nebulous or cometic clouds, and that large planets like Jupiter and Saturn have attached the periodic comets to our system by their attractive power. Between the years 700 and 1200 he concludes that "the solar system was passing through or near a meteoric cloud of great extent; that from 1200 to 1700 it was traversing a region comparatively destitute of such matter and that about the commencement of the eighteenth century it again

entered a similar nebula of unknown extent. The fact that the August meteors were first noticed in 811, renders it probable that the cluster was introduced into the planetary system not long previous to the year 800." "Adopting Struve's estimate of the Sun's orbital velocity, we find the diameter of the nebula traversed in 500 years to be fourteen times that of Neptune's orbit." Professor Kirkwood's paper gives many details supporting his views.

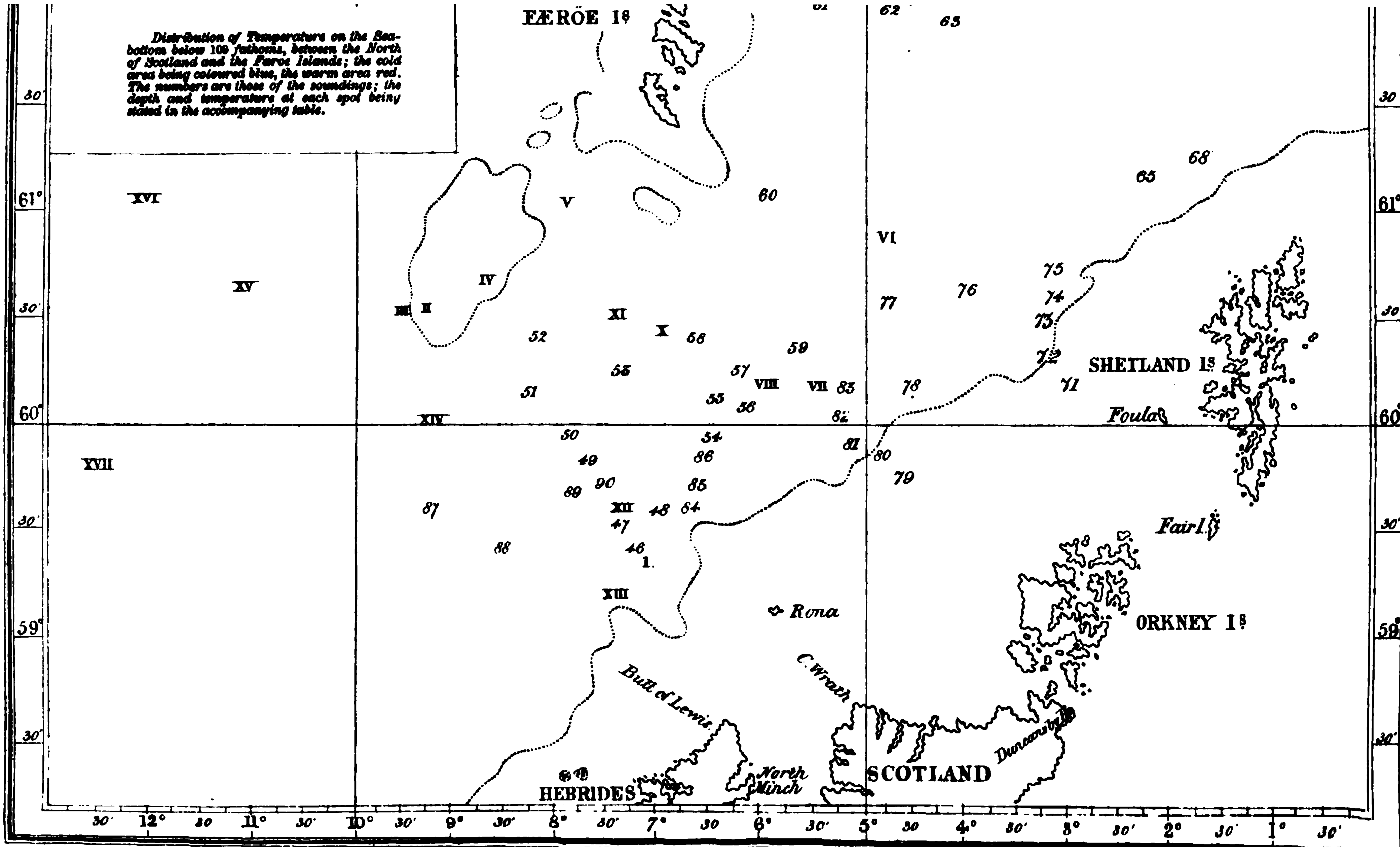
On the Range of Thunder-Storms.—The following observations are recorded as a contribution towards completing the collection of data upon atmospheric electricity :—

About a year and a half since, the writer observed from New Brighton, in Cheshire, a peculiar light flashing among the clouds that were piled up in masses on the horizon. It was in the evening, before dark. The light alluded to was limited to a particular part of the horizon (in direction about N.N.E.), and extended for only about five or six degrees in breadth and height, keeping up a constant flickering motion from behind and among the clouds. On the same evening a terrible storm was raging off the Northumbrian coast, and was felt severely about Holy Island. It may be remarked that the appearance, from New Brighton, was quite distinct from that of sheet lightning, and there was no diffused reflection of light.

Another instance of an actual thunder-storm, visible in this limited and local way, occurred on the evening of September 5th. We may notice here that the previous week had an average temperature of only 54°, while the one preceding that averaged 82°. A great electrical disturbance followed the decrease of temperature.

On this occasion, the appearance of the storm from the neighourhood of Liverpool was a flashing yellowish and greenish light, much more distinct, and of greater extent than the first-mentioned one. It was, however, quite as local and definite in position on the horizon, and seems to have been felt chiefly about Barugh Hill and Stanningley, in Yorkshire. At the first place forty sheep were killed; and two persons met with a tragic fate while walking between Stanningley and Farsley.

Another storm, that broke in London about the same time last year, which was attended by no thunder or lightning, in our neighbourhood, seemed to produce a considerable extent of nervous excitation among persons subject to this feeling, and remarks were made in anticipation of a coming storm. Neither thunder nor lightning, however, were perceived about Liverpool.



Distribution of Temperature on the Sea-bottom below 100 fathoms, between the North of Scotland and the Faroe Islands; the cold area being coloured blue, the warm area red. The numbers are those of the soundings; the depth and temperature at each spot being stated in the accompanying table.

THE DEEP SEA.

PART I.—ITS PHYSICAL CONDITION.

BY WILLIAM B. CARPENTER, M.D., F.R.S.

(*With Two Plates.*)

THE Physical and Biological condition of the Deep Sea, even in close proximity to our own shores, has until lately been almost as completely unknown as that of the ice-bound Polar regions, to which our most adventurous voyagers have hitherto failed in gaining access, or of the interiors of the densest forests and most arid desert-wastes, or of the most inaccessible mountain-summits, that elsewhere still defy the hardihood of our most daring explorers. But while it may be expected that the whole Land-surface of our globe may ultimately be brought under the direct survey of its master—Man, it would seem altogether chimerical to imagine that he can ever extend that survey to the abyssal depths of the Ocean; for although he can ascend a mountain so lofty that the pressure of the Atmosphere is reduced at its summit to considerably less than *one-half* that to which he is subjected at its base, the depth at which he can sustain life beneath the surface of the sea is extremely limited. For even at a depth of about thirty-two* feet ($5\frac{1}{3}$ fathoms) the pressure of the water above him is equal to that of the atmosphere, whilst at four times that depth (128 feet, or $21\frac{1}{3}$ fathoms) the pressure of the superincumbent water is equal to that of four atmospheres; so that whilst a diver working at the former depth is subjected to *double* the ordinary atmospheric pressure, a diver descending to the latter would have to sustain *five times* that under which he ordinarily lives.† Even supposing that means could be devised to afford him a continuous supply of air under such pressure, it would produce so great a disturbance in his bodily functions that he could not long support it; and it is found in practice that divers cannot remain for any length of time at a greater depth than ten, or at most twelve fathoms. The only mode, therefore, in which the Ocean-depths can be explored, is the sending down into them such instruments as may furnish information in regard to their physical conditions, and bring

* A column of 33 feet of *fresh* water is commonly ranked as the equivalent of one Atmosphere, but the weight of a column of 32 feet of *sea* water is nearly the same.

† The pressure of the Atmosphere on the body of an average-sized man may be estimated at about *fifteen tons*. If such a man be submerged, therefore, to a depth of 32 feet, he would have to sustain a pressure of *thirty tons;* while, if he sinks to 128 feet, the total pressure on his body will be *seventy-five tons*.

up samples both of the surface-deposits on the sea-bed and of the living organisms it supports. The improvements which have been made of late in these instruments, and in the mode of working them, have already fructified in an abundant harvest of novel and important results; and these can only be regarded as giving a foretaste of what may be expected from the continued prosecution of the same methods of inquiry.

The object of the present paper is to give an outline of the *physical condition* of the Deep Sea, as made known by the recent explorations in which it has been the writer's good fortune to have borne a part. An account of the *animal life* which inhabits it, as revealed by the investigations not only of his colleagues and himself, but by those of their predecessors in the same line of inquiry, is reserved for a future number.

The British explorations may be said to have had their origin in the success of the deep-sea dredgings carried on by M. Sars, jun. (son of the late lamented Professor Michael Sars), who, as Inspector of Fisheries to the Swedish Government, had the opportunity of prosecuting them off the Loffoden Islands, and other points of the coast of Norway. Besides adding greatly to our Zoological knowledge by the number of new forms they brought to light, these dredgings indicated that types of animal life previously supposed to have been peculiar to past Geological epochs, and to have long since ceased to exist, still have their abode in the abyssal depths of the ocean.—A proposal that the British Government should be asked to take part in like explorations elsewhere, having been made in the spring of 1868 by Professor Wyville Thomson of Belfast, was submitted by the writer to the president and council of the Royal Society, and by them strongly recommended to the Admiralty; which accordingly assigned for the service the Surveying vessel "Lightning," and provided her with the best appliances that could be got ready on so short a notice. The scientific work of this expedition, which was specially directed to the exploration of the deep channel which lies between the north of Scotland and the Faroe Islands, was carried on by Professor Wyville Thomson and the writer; and although necessarily limited in time, and much interfered with by bad weather, it afforded results of such interest, in regard both to the physical conditions and the animal life of the ocean depths, as to excite a strong desire that the inquiry should be taken up more systematically, and prosecuted on a more extended scale.

An application to the Admiralty for the requisite assistance was

accordingly made by the Council of the Royal Society in the spring of last year; and the Surveying vessel "Porcupine," with her excellent staff of officers and men, was assigned for the purpose during the whole season, and was equipped with all the appliances that previous experience had shown to be desirable.

The Expedition of the "Porcupine" was divided into three Cruises. The *first* of these, which was placed under the scientific charge of Mr. J. Gwyn Jeffreys, F.R.S., accompanied by Mr. William L. Carpenter as chemical assistant, commenced from Galway, near the end of May, and concluded at Belfast, at the beginning of July. It was directed in the first instance to the south-west, then to the west, and finally to the north-west as far as the Rockall Bank. The greatest depth to which temperature-sounding and dredging were carried in this cruise was 1476 fathoms; and these operations, through the excellent equipment of the "Porcupine," and the skill of her commander, Captain Calver, were so successfully performed, that it was confidently anticipated that still greater depths might be reached with an equally satisfactory result.

The *second* Cruise, which was under the scientific charge of Professor Wyville Thomson, F.R.S., with Mr. Hunter, of Queen's College, Belfast, as chemical assistant, was consequently directed to the nearest point at which a depth of 2500 fathoms was known to exist, viz., the northern extremity of the Bay of Biscay, about 250 miles to the west of Ushant. In this cruise temperature-sounding and dredging were carried down to the extraordinary depth of 2345 fathoms, or *nearly three miles*—a depth nearly equal to the height of Mont Blanc, and exceeding by more than 500 fathoms that from which the Atlantic Cable was recovered. This sea-bed, on which the pressure of the superincumbent water is nearly *three tons for every square inch*, was found to support an abundance of animal life; about one and a half hundred weight of "Atlantic mud," chiefly consisting of *Globigerinæ*, having been brought up in the dredge, together with various types of higher animals, Echinoderms, Annelids, Crustaceans, and Mollusks; among them a new Crinoid—referable, like the *Rhizocrinus*, whose discovery by M. Sars, jun., had been the starting-point of the present inquiry—to the *Apiocrinite* type which flourished during the Oolitic period.

The *third* Cruise was under the scientific charge of the writer, with Mr. P. H. Carpenter as chemical assistant; but he had the great advantage of being accompanied by his colleague Professor Wyville Thomson, who, as in the "Lightning" expedition, took the

entire superintendence of the dredging operations. The object of this cruise, which commenced in the middle of August and terminated in the middle of September, was a more thorough exploration of the area between the North of Scotland and the Faroe Islands; this having been found in the "Lightning" expedition to afford results of peculiar interest in regard alike to the inequality of Temperature and to the distribution of Animal life on the sea-bed, which here ranges between the comparative shallow depths of from 350 to 650 fathoms—the last named being the greatest depth to which dredging had been carried in 1868.

Before proceeding to state the results of these inquiries, it will be desirable to give some account of the means by which they have been obtained.

The first point to be determined in the exploration of what are often called the "fathomless abysses" of the Ocean, is their actual *depth*. This, it might be supposed, would be very easily ascertained by letting down (as in ordinary Sounding) a heavy weight attached to a line strong enough to draw it up again, until the weight touches the bottom; and then to measure the amount of line it has carried out. But this method is liable to very great error. Although a mass of lead or iron thrown freely into the water would continue to descend at an increasing rate (at least until the friction of its passage should neutralise the accelerating force of gravity), the case is quite altered when this mass is attached to the end of a rope, of which the immersed length increases as the weight descends. For the friction of the rope comes to be so great when a mile or more has run out, as seriously to reduce the rate of descent of the weight, and at last almost to stop it; and as the rope will still continue to descend by its own gravity (which, when it is immersed, considerably exceeds that of water), any quantity of it may be drawn down, without the bottom being reached by the weight at its extremity. Further, if there should be any motion, however slow, in the water through which it passes, this current acting continuously against the extended surface presented by the rope, will carry it out into an almost horizontal loop, the length of which will depend upon the rate of the flow and the time during which the rope is exposed to it. Under such circumstances it is impossible that the impact of the weight upon the bottom, even if it should really reach it, can become perceptible above; and thus the quantity of rope which may have run out affords no indication of the actual depth of the sea-bed beneath the surface. Hence all those older Soundings which were supposed to justify the statement that the bottom of

the ocean is not less in some places than six or eight miles from the surface, or may be even absolutely fathomless, are utterly unreliable; and no value can be attached to any of these that exceed a few hundred fathoms.

Various methods have been devised for obtaining more correct measurements; but it is not worth while to describe any, save such as have stood the test of experience; and there is now a general agreement as to the principle on which an efficient Sounding-apparatus should be constructed, although there are several different arrangements for giving to it practical effect. The principle is that regard should be had in the first instance, not to recovering the plummet, or "sinker," which is a matter of quite subordinate consideration; but to securing the vertical direction of the line to which it is attached, so that the measurement of the amount run out may give as nearly as possible the actual depth of the water through which the sinker has fallen. The earliest mode of Sounding on this principle was a very simple one. A cannon-ball is attached to a reel of twine, of known length, made to turn very easily; the shot being let-go, and allowed to descend as fast as it reels off, reaches the bottom with the least possible impediment; and a breaking strain being then put on the line, the depth is estimated by subtracting from its entire length the portion still remaining on the reel. This method, however, has not been found to answer in practice. For if the line be not strong enough to allow of being put strongly on the stretch, it cannot communicate the shock of the impact of the cannon-ball upon the sea-bottom; and its want of tension renders it liable to be acted on both by gravity and by ocean currents, to such a degree that it continues to run out indefinitely, long after the sinker may be supposed to have reached the bottom. It is an additional objection to this method, that even if it could be worked in such a manner as to give true results, these data would be far from satisfactory: since we desire to know not merely the *depth* of the ocean-bed at various points, but *the nature of the bottom;* in addition to which it has now become a matter of essential importance to ascertain the *temperature* of the bottom-water; whilst it is also desirable to obtain a sample of that water, for determining the composition of the *gases* as well as of the *solid matters* which it holds in solution.

For the attainment of these objects, it is now found expedient to adopt the following plan:—The sinker is connected, not with the line itself, but with an apparatus which is so constructed as to detach it when it touches the bottom; and the line is made sufficiently

strong not only to bear a considerable tension as the weight descends, but also to pull up the carrying apparatus, with any instruments attached to it, when the weight has been left below. The shock of its impact against the bottom, even at a depth of three miles, can then be distinctly recognized by a practised hand; and as a line of the required strength can be made small enough to run out very easily, its vertical direction can be pretty well secured, even at great depths, if the operation be carried on by an officer of ability and experience. For work of this kind, a Steam-vessel has a great advantage over a Sailing-vessel; since the former can be much more readily kept directly over the line of vertical descent, so as to obtain that true "up-and-down" sounding which is required for the correct estimation of the depth.

The *nature of the bottom* is ascertained in ordinary shallow-water Sounding by the examination of the small sample that may adhere to a lump of tallow introduced into a hollow at the bottom of the plummet. But for deep-sea Soundings it is desirable to employ some arrangement, whereby a larger sample may be brought up without any admixture of tallow; and for doing this, various contrivances have been devised. When the depth does not exceed 1000 fathoms, so as to permit the use of an ordinary cylindrical deep-sea lead, weighing one hundredweight, which can be pulled up again by the line, nothing is more simple and effective than a conical cup attached beneath this, having a circular lid so fitted as to fall down and close it when an upward movement is given to the lead. For if the cup should penetrate into sand or mud, it fills itself with this before the lid falls down; while the subsequent closure of its mouth prevents its contents from being washed out, while the lead is rising to the surface. During the Sounding voyage of the "Bulldog" an apparatus was devised by Dr. Wallich, which, as having been subsequently much employed by Swedish explorers of the deep sea, merits special notice. This is constructed somewhat on the plan of a bullet-mould; two hemispherical cups, which are kept apart while the apparatus is descending, being brought together by a spring which comes into action when the sinker detaches itself on reaching the bottom, so that a sample of the mud or sand into which they may have penetrated is enclosed between them. This "Bulldogsmaskinen," as it was termed by Professor Sars, has been very effectively used for obtaining not merely samples of any deposit covering the sea-bed, but also specimens of the animal life which it may support. It is obvious, however, that the information it can afford in regard to the latter must be very limited in comparison with that obtained by the use of the Dredge; since the forceps can

only enclose what happens to lie between them at the spot which they strike.

The sounding instrument now preferred in the British service is known as the "Hydra" apparatus; having been devised by Capt. Shortland, of Her Majesty's surveying ship "Hydra." It consists of a strong tubular rod, furnished with valves that open upwards, so as to allow the water to stream through it freely in its descent, whilst the mud or sand into which the tube is forced on reaching the bottom, is prevented by their closure from escaping. This is loaded with sinkers; which are masses of iron, each weighiug one hundredweight, having the shape of a cheese, with a perforation in the middle for the passage of the rod. One, two, or three of these sinkers may be hung upon it, in such a manner as to rest securely on their support whilst the apparatus is descending, but to fall off as soon as the rod strikes.

In the recent "Porcupine" expedition, the one hundredweight deep-sea lead with a conical cup was employed for Sounding, when the depth was not supposed to exceed 1,000 fathoms. For soundings between 1,000 and 1,500 fathoms, the "Hydra" apparatus with two sinkers was employed; and for depths greater than 1,500 fathoms, three sinkers were used. The line to which these were attached was specially made for the purpose, of the best Italian hemp; and although not thicker than an ordinary lead pencil, it bears a strain of twelve hundredweight. It was allowed to run out as fast as the weight would carry it down, a moderate strain being kept upon it; and was reeled in by the donkey-engine provided for working the dredge.

The following particulars of the deepest Sounding taken in this expedition will be interesting; since, though not the deepest on record, it is one of the deepest yet made which is thoroughly reliable, having been taken with the most perfect appliances, and managed by an Officer of the greatest skill and experience, to whose practised hand the shock of the arrest of the weight at the bottom was distinctly perceptible, though this took place at a depth of nearly *three miles.*

Fathoms.	Time.	Fathoms.	Time.	Fathoms.	Time.
	Min. Sec.		Min. Sec.		Min. Sec.
100	0 45	900	1 22	1700	1 37
200	0 40	1000	1 15	1800	1 47
300	0 46	1100	1 21	1900	1 47
400	0 55	1200	1 21	2000	1 47
500	0 50	1300	1 23	2100	1 49
600	1 00	1400	1 32	2200	1 55
700	1 09	1500	1 32	2300	1 59
800	0 59	1600	1 33	2435	1 92

The whole time occupied in the descent was thirty-three minutes thirty-five seconds; and the rate at the end was about one-third of the rate at the commencement, the retardation being on the whole very regular. The reeling-in, which required great caution in order to avoid putting an undue strain on the line, its friction resistance being much greater than the weight it carried, occupied two hours two minutes.

The *pressure* exerted by the water of the Ocean upon whatever is submerged in its abysses, may be readily calculated when the depth is known. The weight of a column of sea-water, one inch square, is almost exactly a ton for every 800 fathoms of its height; and consequently the pressure upon the bottom at 2435 fathoms depth is rather over *three tons upon every square inch.* This, however, has but very little effect upon the *density* of the water; for the compressibility of water is so slight that even the pressure just mentioned would certainly not reduce it by one-fortieth of its volume, or produce an increase in its density equalling the difference between salt and fresh water. The popular notion, therefore, that a mass of iron or lead thrown into the sea would encounter so rapid an increase in density of the water through which it sinks, that the deeper strata of the liquid would equal or even exceed the metal in density, and would thus hold it in suspension or even buoy it up, is altogether unfounded. Not less unfounded are the statements that have been put forward upon professedly scientific authority, as to the effects which such pressure must exert upon any substances, whether mineral or organic, that may be exposed to it. Thus it has been asserted in an "Advanced Text Book of Geology," that "at great depths sand, mud, and all loose débris will be compressed and consolidated;" as if these substances were being squeezed in a Bramah press, which should force out all their liquid, and bring their solid particles into the closest possible contact. The fact, now ascertained beyond all doubt, that sand or mud retains its ordinary condition at a depth of nearly three miles, under a pressure of more than three tons on the square inch, is perfectly accordant with the law of fluid pressure; for as such pressure acts equally in all directions, it will be exerted just as much in forcing in water between the solid particles, as it is in pressing these particles together; and thus, an equilibrium being uniformly maintained, the loose sand or mud of shallow water would remain absolutely unchanged in its condition, to whatever depth the bottom might subside. The same principle will be hereafter shown to apply to the case of animals whose bodies are composed of solids and liquids

alone; such animals being able to "live, and move, and have their being" under the enormous pressure just mentioned, in virtue of its uniformity of distribution. The case is quite different, however, in regard to substances containing *air;* for this, under great pressure will either be forced out, or be reduced to extremely small proportional dimensions, its place being taken by liquid. Thus it has happened that a boat having been dragged down by a whale to great depths, the wood of which it was made sank in water like a stone, and this not only when it was first recovered from the sea, but for a long time afterwards. And in like manner not only the bodies of air-breathing animals, but those of fish provided with swimming bladders, would undergo great changes in size and form when submerged to great depths, owing to the extreme reduction in the bulk of their air-cavities.

The Pressure of ocean-waters has been lately found by experiment to exert an influence of which the amount had been previously unsuspected, on the Thermometers used for one of the most important portions of deep-sea research—the determination of the *temperature* at different depths, and in different strata of the ocean-waters. As will be presently shown, it is on the careful study of the records of self-registering thermometers attached to the sounding apparatus, that we depend for our knowledge not only of those differences of Submarine Climate by which the distribution of Animal life is mainly regulated, but of those great undercurrents that form an essential part of the great system of Oceanic Circulation, which modifies in a greater or less degree the terrestrial climate of every region not too far removed from its influence. No determination of deep-sea temperatures can be of the least value, unless either the instruments employed are furnished with a special protection which removes them from the influence of pressure, or their error has been experimentally tested at pressures corresponding to different depths. And all these older observations, on which was based the doctrine of a uniform temperature of 39° in very deep water all over the globe (adopted by Sir John Herschel in his "Physical Geography," 1861), must now be put aside as utterly unreliable.

All the Temperature-soundings of the "Porcupine" expedition were taken with self-registering instruments of the construction known as Six's, which had been specially protected from the effects of pressure by the enclosure of the bulb of each instrument in an outer bulb, sealed round the neck of the tube; about three-fourths of the intervening space being filled with spirit, but a small vacuity

being left, by which any reduction in the capacity of the outer bulb is prevented from communicating pressure to the inner. This plan of construction, which was suggested by Prof. W. A. Miller, has been so successfully carried into practice by Mr. Casella, that Thermometers thus protected have been subjected to a pressure of *three tons on the square inch*, in a testing-machine devised for the purpose, without undergoing more than a very slight elevation, of which a part (at least) is attributable to the heat given out by the compression of the water in which they were immersed; whilst the very best thermometers of the ordinary construction were affected by the same pressure to the extent of 8° or 10°, the elevation in some instruments reaching as much as 50° or 60°.* Two of these protected Miller-Casella thermometers were used in each observation; and they always agreed within a fraction of a degree. The same pair was used throughout the expedition; and notwithstanding that they were used for 166 separate observations, in which they travelled up and down nearly 100 miles, they came back in perfectly good order,—a result mainly due to the care with which they were handled by Captain Calver. It may be affirmed with great confidence that the temperatures which they indicated were correct within 1° (Fahr.); an approximation quite near enough for the scientific requirements of the case. The thermometers are enclosed in cylindrical cases, having holes in the top and bottom, through which the water can stream freely during their descent and ascent; and these cases are attached to the sounding line just above its termination. The recorded temperature will nearly always be the *minimum* encountered by the instrument; the only cases in which the temperature of the deep water *exceeds* that of the surface, being those in which a submarine spring discharges warm water from the interior of the earth. It does not necessarily follow, however, that the *minimum* temperature should be that of the *bottom*; but such, as is shown by the observations made in the "Porcupine" expedition, will always be the case, unless there should be some local peculiarity of bottom or current that brings a deep and cold stratum nearer to the surface than that under which it normally lies. In order to determine whether the rate of diminution of temperature

* See Prof. W. A. Miller's "Note upon a Self-Registering Thermometer, adapted to Deep-Sea Soundings," in "Proceedings of the Royal Society," June 17, 1869.—The same principle had been previously applied in thermometers constructed under the direction of Admiral Fitzroy; the space between the two bulbs, however, being occupied with mercury instead of spirit. Owing, however, to some imperfection in their construction, their performance was not satisfactory, and they were found very liable to fracture.

is uniform from above downwards, it is necessary to take a *series* of Temperature-soundings in some one spot; the temperature at successive depths (say at every 50, 100, or 250 fathoms, according to circumstances) being determined by letting down the instrument to the depth required, and then drawing it up again and noting the *minimum* recorded.

In this manner the data were obtained which gave the remarkable results represented in Diagrams I.—IV.; from which it may be inferred, almost with certainty, that the depression of temperature observable in the deepest parts of the great Ocean-basins, is due to the discharge into them of streams of Polar water, which may diffuse a glacial coldness over the sea-bed far into the Temperate Zone.

Another instrument which was employed in the "Porcupine" expedition with very important results, in connection with the sounding-apparatus, is a *water-bottle* for the collection of samples of water either from the bottom or from any intermediate stratum. This is simply a strong cylindrical vessel of brass, furnished at the top and bottom with a conical valve opening upwards, and holding about 60 oz. of water. While this bottle is descending through the water with the sounding apparatus, the valves readily yield to the upward pressure, and a continuous current streams through it; but as soon as the descent is checked, either by the arrival of the apparatus at the bottom, or by a stop put on the line from above, the valves fall into their places, and thus enclose the water that may fill the bottle at the moment. The expansion of this water and of its dissolved gases, as the bottle is brought to the surface, causes a pressure from within, which lifts the upper valve so as to permit the escape of any part of the contents of the bottle that may be in excess of its capacity. Of the water thus obtained, some samples were carefully preserved for complete analysis at home, especially with a view to the determination of the quantity of Organic matter contained in them. But the greater part of the samples were at once boiled for some time, for the purposes of extracting the gases they might hold in solution; and the proportions of oxygen, nitrogen, and carbonic acid in the mixture of gases thus obtained were carefully determined.

GENERAL RESULTS.

The Temperature observations made during the Lightning expedition of 1868, although made with thermometers unprovided with the protection which has since been found essential to their accurate performance when exposed to great pressures in the deep sea, indi-

cated that two very different Submarine Climates exist in the deep channel which lies E.N.E. and W.S.W. between the North of Scotland and the Faroe Banks; a *minimum* temperature of 32° having been registered in some parts of this channel, whilst in other parts of it, at the *like depths*, and with *the same surface-temperature* (never varying much from 52°), the *minimum* temperature registered was never lower than 46°,—thus showing a difference of 14°. It could not be positively asserted that these *minima* are the *bottom*-temperatures of the areas in which they respectively occur, but it was argued that they must almost necessarily be so: *first*, because it is highly improbable that sea-water at 32° should overlie water at any higher temperature, which is specifically lighter than itself, unless the two strata have a motion in opposite directions sufficiently rapid to be recognizable; and *second*, because the nature of the animal life found on the bottom of the Cold area, which consists of quartzose sand including volcanic particles, exhibited a marked correspondence with its presumed reduction of temperature, being essentially Boreal in its general character; whilst the sea-bed of the Warm area is essentially composed of *Globigerina*-mud, and the animal life which it supports is characteristic of the warmer-temperate seas.

This conclusion, it is obvious, would not be invalidated by any error arising from the effect of pressure on the bulbs of the thermometers; since, although the *actual minima* might be—as was then surmised—from 2° to 4° below the *recorded minima*, the *difference* between temperatures taken at the same or nearly the same depths would remain unaffected. The correctness of this surmise was proved by subsequent experiments; and the numerous observations with "protected" thermometers made during the "Porcupine" survey of the area traversed by the "Lightning" expedition, fully confirm the observations made in the latter, when the requisite correction for pressure (from 2° to 3° according to the depth) is applied to them. (See Map I. and accompanying Table.)

The existence in the Cold area of a *minimum* temperature of 32°, with a Fauna essentially Boreal, could not, it was argued, be accounted for in any other way, than by the supposition of an under-current of Polar water coming down from the north or north-east: whilst, conversely, the existence in the Warm area of a *minimum* temperature of 46°, extending to 500 or 600 fathoms' depth, in the latitude of 60° (being at least 8° above its Isotherm), together with the warmer-temperate character of its

Fauna, seemed equally indicative of a flow of Equatorial water from the south or south-west.

It was further urged that if the existence of two such different submarine climates in close proximity can only be accounted for on the hypothesis of an Arctic stream and an Equatorial stream running side by side (the latter also spreading over the former in consequence of its lower specific gravity), these streams are to be regarded (like the Gulf Stream) as particular cases of a *great general oceanic circulation*, which is continually bringing the water cooled down in the Polar regions into the deepest parts of the Equatorial ocean-basins, whilst the water heated in the Equatorial regions moves towards the Poles on or near the surface. Such a circulation was long since pointed out to be as much a physical necessity, as is that interchange of *air* between the Equatorial and Polar regions, which has so large a share in the production of winds: but whilst Physical Geographers remained under the dominant idea that the temperature of the deep sea is everywhere 39°, they could not fully recognize its importance.

These doctrines have been fully tested by the very numerous and careful temperature-soundings taken in the "Porcupine" expedition; and the result has been not merely to confirm them in every particular—so that they may now take rank as established facts,—but also to show that a Temperature 2½° (Fahr.) *below the freezing point of fresh water* may prevail over the sea-bed in a region far removed from the Polar, and that even this extreme reduction is by no means antagonistic to the existence of Animal life in great variety and abundance.

The general distribution of *bottom*-temperature in the channel between the north of Scotland and the Faroe Banks, is shown in the accompanying Map, the coloured portion of which marks the deeper portion of that channel, bounded on the south-east by the 100 fathom line, and on the north-west by the Faroe Banks. This 100 fathom line may be considered as marking the boundary of the *plateau* on which the British Islands rest, and which extends to some distance around their coasts. An elevation of this *plateau* to the extent of 100 fathoms (600 feet), would convert the whole of it into dry land; and not only would Ireland, the Isle of Man, and the Orkney and Shetland Islands, be brought into continuity with Great Britain, but the bed of the North Sea and of the English Channel would almost everywhere become dry land, and thus the whole British area, with an addition taken into it from the Atlantic, would become continuous with the continent of Europe. It would

still be separated from the Faroe Islands, however, by a channel reaching to 500 fathoms' depth, the south-eastern bank of which is very steep; and it is in this channel that the remarkable phenomenon is presented of a wide and deep stream, bringing a Glacial temperature into the near neighbourhood of the shore of Scotland. The general course of this stream is shown by the *blue* tint. In the north-east portion of the channel, which lies between the Faroe and the northernmost of the Shetland Islands, every part of the bottom that is below 300 fathoms' depth appears to be overflowed by the glacial stream; and though this is everywhere covered by the warmer stratum, which seems to have come thither from the south-west, it is only on the shallower slopes of the channel, that, as indicated by the red tint, this stratum gives its higher temperature to the *bottom*. On the other hand, in the western portion of the deep channel, which lies between the Faroe Banks and the Hebrides, the glacial stream is to be found limited to a comparatively narrow band on its northern side; the higher temperature of the surface-water extending downwards to the bottom of its southern part, and being found to prevail at the like depths in a westerly direction, as far as the great descent which leads to the deeper part of the Atlantic basin. What is the precise cause of the narrowing of the glacial stream in this part of the channel,—whether it is turned aside by a "middle bank," or displaced by the body of warmer water coming to meet it from the south-west,—cannot at present be stated with certainty; nor has its ultimate course yet been traced out. The temperature-phenomena of the Atlantic basin, however, will be presently shown to render it probable that the Glacial stream of what may be termed the "Lightning channel" is discharged into it, together with other streams coming down more directly from the Arctic basin, as indicated by the blue tint over the western portion of the map.

The depths and bottom-temperatures obtained at the several Stations indicated by the numbers on the Map, are given in the accompanying Table; the Roman numerals marking those taken in the "Lightning" expedition of 1868 (with the requisite correction for pressure), and the Arabic figures marking those of the "Porcupine" expedition of 1869. Besides the fifty-one *bottom*-soundings taken in water of more than 100 fathoms' depth, *serial* soundings (p. 234) were taken at successive depths at three Stations. At Station 87, which lay in the Warm area, about 125 miles to the north-west of Stornoway, the temperatures were taken at 50, 100, 150, 200, 300, 400, 500, 600, and 767 fathoms (bottom); and the

rate of diminution of temperature from the surface downwards, amounting in all to 11·2° degrees (Fahr.), is shown in the upper curve of Diagram I. At Station 52, which lay in the Cold area, near the south-east corner of the Faroe Bank, the temperature was taken at every 50 fathoms down to 300, and then at 384 fathoms (bottom); and the rate of diminution from the surface downwards, here amounting in the whole to 21·5° (Fahr.), is shown in the *middle* curve of Diagram I. At Station 64, which also lay in the Cold area, but in the middle of the north-east portion of the channel, the temperature was taken at every 50 fathoms down to 600, and then at 640

DIAGRAM I.

fathoms (bottom); and the rate of diminution from the surface downwards, here amounting in the whole to 20·1°, is shown in the *lower* curve of Diagram I.

The relation between Depth and Temperature in the Warm and

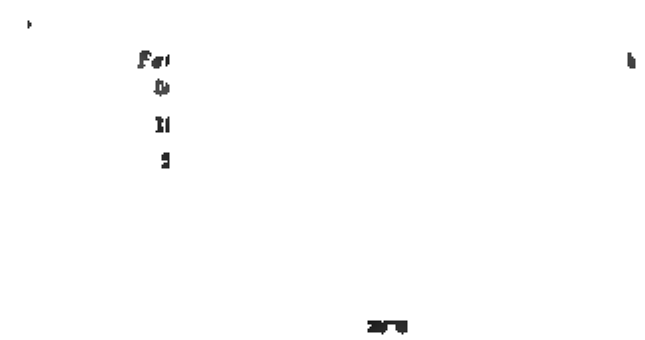


DIAGRAM II. DIAGRAM III.

Cold areas respectively, is well shown in Diagrams II. and III., in which (neglecting fractional parts) each line marks a descent of 1° Fahr.

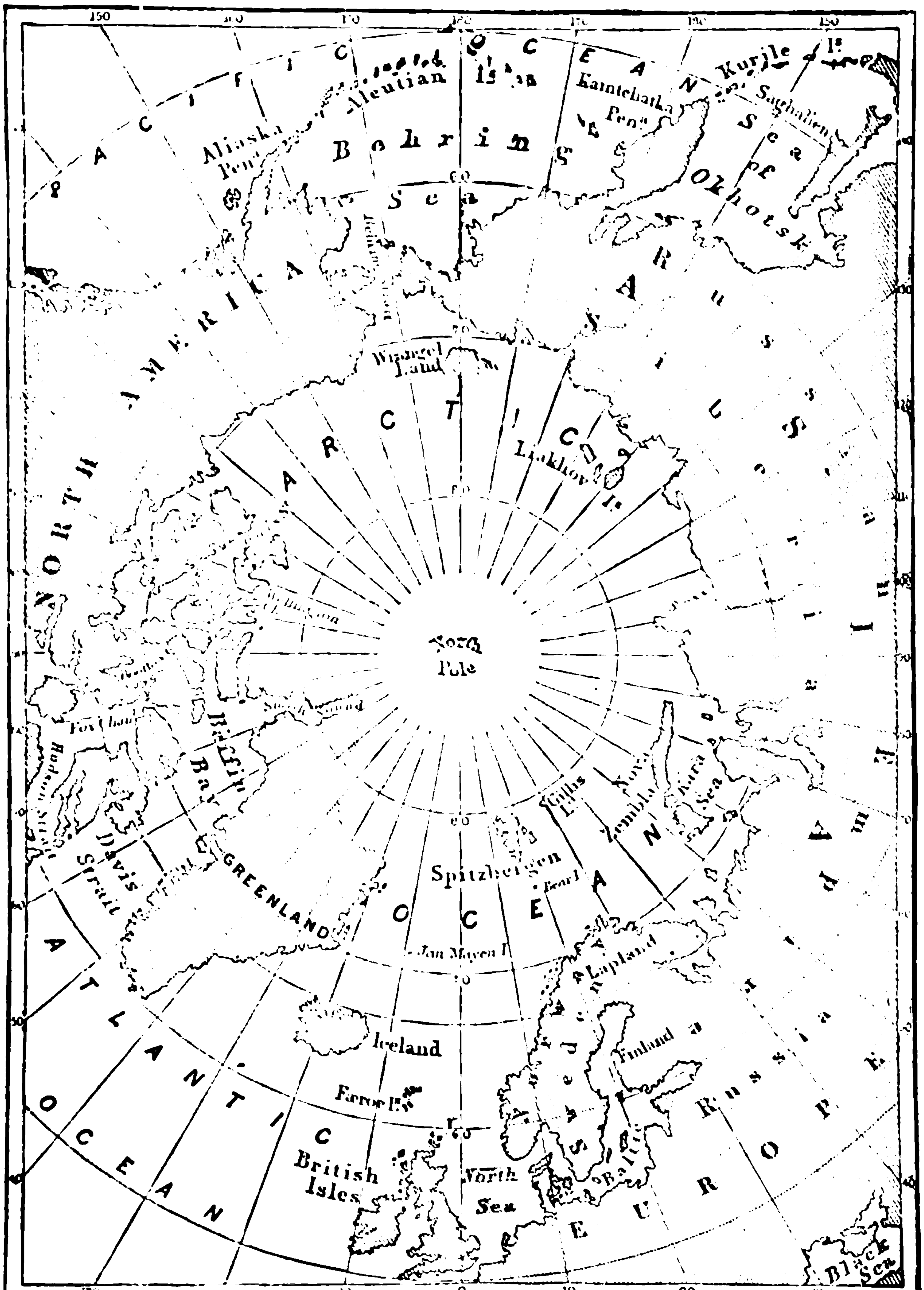
The *surface*-temperature may be said to be everywhere nearly the same, viz. 52°; the variations above or below this being attributable either to atmospheric differences (as wind, sunshine, etc.), or to difference of latitude. Alike in the Warm and the Cold

areas there is a fall of from 3° to 4° in the first fifty fathoms, bringing down the temperature at that depth to 48°. A slow descent takes place nearly at the same rate in both areas through the next 150 fathoms; the temperature in the Warm area at the depth of 200 fathoms being 47°, whilst in the Cold it was 45·7°. It is below this depth that the marked difference shows itself. For whilst in the Warm area there is a slow and pretty uniform descent in the next 400 fathoms, amounting to less than *four degrees* in the whole, there is in the Cold area a descent of *fifteen degrees* in the next 100 fathoms, bringing down the temperature at 300 fathoms to 30·8°. Even this is not the lowest; for the serial soundings taken at depths intermediate betweeen 300 and 640 fathoms (the latter being the greatest depth met with in the Cold area) showed a further progressive descent; the lowest bottom-temperature met with being 29·6°.

Thus, while the temperature of the superficial stratum of the water occupying the Cold area, clearly indicates its derivation from the same source as the general body of water occupying the Warm area, the temperature of the deeper stratum, which may have a thickness of more than *two thousand* feet, ranges from the freezing-point of fresh water to 2½° below it. Between the two is a *stratum of intermixture* of about 100 fathoms thickness, which marks the transition between the warm superficial layer, and the body of frigid water which occupies the deeper part of the channel.

The shortest distance within which these two contrasted Submarine Climates were observed at corresponding depths, was about 20 miles; but a much smaller distance was sufficient to produce it when the depth rapidly changed. Thus near the southern border of the deep channel, at a depth of 190 fathoms (Station 85), the bottom-temperature was 48·7°; while *only six miles* off, where the depth had increased to 445 fathoms (Station 86), the bottom temperature was 30·1°. In the first case, the bottom evidently lay in the warm superficial stratum; whilst in the second it was overflowed by the deeper Glacial stream.

It seems impossible to account for these phenomena, on any other hypothesis than that of the *direct derivation of this frigid water from the Arctic basin.* And this agrees very well with other facts observed in the course of the exploration. Thus:—(1.) The rapid descent of temperature marking the "stratum of intermixture" began about 50 fathoms nearer the surface in the most northerly portion of the cold area examined, than it did in the most southerly, as might be expected from the nearer proximity of the cold stream



PACIFIC OCEAN
Aleutian Is
Aliaska Pen
Behring Sea
Kamtchatka Pen
Kurile Is
Saghalien
Sea of Okhotsk
NORTH AMERICA
Wrangel Land
ARCTIC OCEAN
Liakhov Is
North Pole
Smith Sound
Baffin Bay
Davis Strait
GREENLAND
Spitzbergen
Bear I.
Jan Mayen I.
Nova Zembla
Kara Sea
Lapland
Iceland
Feroe Is
British Isles
North Sea
Finland
Russia
Baltic
ATLANTIC OCEAN
EUROPE
Black Sea
RUSSIA IN ASIA

to its source. (2.) The sand covering the bottom contains particles of volcanic minerals, probably brought down from the Faroe Islands, Jan Mayen, or Spitzbergen. (3.) The Fauna of the cold area has a decidedly Boreal type; many of the animals which abound in it having been hitherto found only on the shores of Greenland, Iceland, or Spitzbergen.

Although the Temperatures obtained in the Warm area do not afford the same striking evidence of the derivation of its whole body of water from a Southern source, yet a careful examination of its condition seems fully to justify such an inference. For the water at 400 fathoms in Lat. 59½° was only 2·4° colder than water at the same depth at the northern border of the Bay of Biscay, in a latitude more than 10° to the south, where the surface-temperature was 62·7°; and the approximation of the two temperatures is yet nearer at still greater depths, the bottom-temperature at 767 fathoms at the former station being 41·4°, whilst the temperature at 750 fathoms at the latter point was 42·5°. Hence, as it may be certainly affirmed that the lowest temperature observed in the Warm area is considerably above the Isotherm of its latitude, and that this elevation could not be maintained against the cooling influence of the Arctic stream but for a continual supply of heat from a warmer region, the inference seems inevitable that the bulk of the water in the warm area must have come thither from the south-west.

Now the influence of the Gulf Stream proper (meaning by this the body of superheated water which issues through the "Narrows" from the Gulf of Mexico), if it reaches this locality at all—which is very doubtful—could only affect the *most superficial* stratum; and the same may be said of the surface-drift caused by the prevalence of south-westerly winds, to which some have attributed the phenomena usually accounted for by the extension of the Gulf Stream to these regions. And the presence of the body of water which lies between 100 and 600 fathoms' depth, and the range of whose temperature is from 48° to 42°, can scarcely be accounted for on any other hypothesis than that of a *great general movement of Equatorial water towards the Polar area;* of which movement the Gulf Stream constitutes a peculiar case modified by local conditions. In like manner, the Arctic Stream which underlies the warm superficial stratum in our Cold area, constitutes a peculiar case, modified by the local conditions to be presently explained, of *a great general movement of Polar water towards the Equatorial area,* which depresses the temperature of the deepest parts of the great oceanic basins nearly to the freezing-point.

During the *first* and *second* cruises of the "Porcupine," the Temperature of the eastern border of the great North Atlantic basin was examined at various depths between from 54 to 2435 fathoms, and in widely different localities, ranging from lat. 47° to lat. 55°. The *bottom*-temperature was ascertained at 30 stations, and *serial* soundings were taken at 7 stations; making the total number of observations 84. Amongst all these the coincidence of temperatures at corresponding depths is extraordinarily close; the chief differences showing themselves in the temperature of the *surface* and of the stratum immediately beneath it.

The superheating of the surface-stratum, which sometimes amounts to more than 10°, and was distinguishable by the small depth to which it extended, was found to be more marked (as might be expected) at the southern than at the northern stations. Whether it is entirely due to the direct influence of Solar heat, or depends in any degree on an extension of the Gulf Stream as far as the southern part of the area examined, is a question which can only be resolved by the determination of its relative amount at different seasons.

DIAGRAM IV.

Putting this aside, and taking 54° as the ordinary surface-temperature (this having been its average at those stations in which there was no conspicuous superheating), the general relation between temperature and depth in the Atlantic basin is indicated in Diagram IV., which is constructed on the same plan and scale as Diagrams II. and III., with which it may be advantageously compared.

Between 100 and 500 fathoms the rate of depression is very slow, averaging only about 3° in the whole, or three-fourths of a degree for every 100 fathoms; and this body of water has a temperature so much above the Isotherm of the northern stations at which the observations were made, as decidedly to indicate that it must have found its way thither from a southern source. Between 500 and 750 fathoms, however, the rate of decrease becomes much more rapid, the reduction being 5·4°, or above 2° per 100 fathoms; while between 750 and 1000 fathoms it amounts to 3·1°, bringing

down the temperature at the latter depth to an average of 38°·6. Beneath this there is still a slow progressive reduction with increase of depth, the temperature falling a little more than 2° between 1000 and 2435 fathoms; so that at the last-named depth, the greatest at which it was ascertained, it was 36·5°.

Now, on comparing the rate of depression of Temperature in successive strata of this deep Atlantic basin, with that which has been shown to exist in the thinner strata of our comparatively shallow Cold area, a very remarkable relation presents itself; the Thermometric changes requiring in the former case a much greater Bathymetric descent than in the latter, but corresponding very closely with them when this allowance is made. This relation may be presented to the mind by ideally extending Diagram III. in a vertical direction, so that its horizontal lines should be separated by much wider intervals. It has been pointed out (p. 240) that in the latter the stratum of about 100 fathoms which lies below the superficial 50, shows but a very slight decrease of temperature; presenting almost exactly the same rate of descent as the stratum between similar depths in the neighbouring Warm area. Now, with this 100 fathoms' stratum, a stratum of about 500 fathoms beneath the superficial 100 in the deep Atlantic very closely corresponds; the reduction down to 500 fathoms being at an extremely slow rate. Between 150 and 300 fathoms in the Cold area, however, the rate of reduction becomes very much greater; and this is just what presents itself in the Atlantic basin between 500 and 1000 fathoms; so that as in the Cold area we come down at very little below 300 fathoms upon a stratum of glacial water, so in the Atlantic basin we come down at 1000 fathoms upon a stratum averaging 38·6°. And further, as there is below this a progressive diminution of about 2° as we descend through the lower 300 fathoms of the Cold area, so a like progressive diminution is shown as we descend through the lower 1000 fathoms of the deep Atlantic basin.

If, then, it be assumed that the body of glacial water brought down from the Arctic basin by the various Polar currents, is discharged into the wide and deep Atlantic basin, it will tend to diffuse itself over its bottom, partly displacing, and partly mingling with, the water which previously occupied it; so as to form a stratum of considerable thickness, which, while much colder than the water nearer the surface, has lost the extreme frigidity which characterizes the current at a comparatively small depth when it comes fresh from the Arctic basin. And just as the rapid descent of tem-

perature between 150 and 300 fathoms in the cold area, may be taken to indicate that this is the *stratum of intermixture* between the warm superficial stream coming from the southward, and the deep flow of glacial water coming from the northward, so may the like rapid diminution between 500 and 1000 fathoms in the Atlantic basin, be taken as indicating that this is the *stratum of intermixture* between the great body of surface-water carrying a higher temperature from the Equatorial towards the Polar regions, and the diluted Polar stream which seems to occupy all the deeper parts of the basin to within about 1000 fathoms of the surface, and thus carries back Polar water to the Equatorial area.

The Temperature-soundings recently taken by Commander Chimmo, R.N., and Lieutenant Johnson, R.N., at various points in the North Atlantic basin, when the requisite corrections are applied for the influence of pressure on the bulbs of the unprotected thermometers employed by them, give results which are remarkably accordant with our own; so that it may be stated with confidence that the temperature of the deeper parts of the North Atlantic sea-bed is but a very few degrees above the freezing-point.

Now a glance at the North Polar region, as laid down either on a Globe or on any projection of which the pole is the centre (Map II.), shows that the Polar basin is so much shut in by the northern shores of the European, Asiatic, and American continents, that its only communication with the North Atlantic basin—besides the circuitous passages leading into Hudson's and Baffin's Bays—is the space which intervenes between the eastern coast of Greenland and the north-western portion of the Scandinavian peninsula. If, therefore, there be any such general interchange of Polar and Equatorial water as that for which we have argued, the Arctic stream *must* flow through the deeper portions of this interspace, at the north of which lies Spitzbergen, whilst Iceland and the Faroes lie in the middle of its southerly expanse. Now in the channel that lies between Greenland and Iceland, the depth is such as to give a free passage to such a frigid stream; but between Iceland and the Faroe Islands there is no depth so great as 300 fathoms at any part, except in a narrow channel at the south-east corner of Iceland; so that an effectual barrier is thus interposed to any movement of frigid water at a depth exceeding this. A similar barrier is presented, not merely by the plateau on which the British Islands rest, but also by the bed of the North Sea; the shallowness of which must give to such a movement a not less effectual check than would be afforded by an actual coast-line uniting the Shetland Islands and Norway.

Consequently, it is obvious that a flow of ice-cold water, at a depth exceeding 300 fathoms from the surface, down the north-eastern portion of this interspace, *can* only find its way southwards through the deeper portion of the channel between the Faroe and Shetland Islands, which will turn it into a W.S.W. direction between the Faroe Islands and the north of Scotland, and finally discharge such part of it as has not been neutralized by the opposing stream coming up from the south-west, into the great North Atlantic basin, where it will meet the Icelandic and Greenland currents, and unite with them in diffusing frigid waters through its deeper portion. In thus spreading itself, however, the frigid water will necessarily mingle with the mass of warmer water which it there meets, and will thus have its own temperature raised, whilst lowering the general temperature of that mass; and hence it is that we do not find the temperature of even the greatest depths of the Atlantic basin nearly so low, as that of the comparatively shallow channel which feeds it with Arctic water.

It may be questioned, however, whether the whole body of Arctic water that finds its way through the channels just indicated, could alone maintain so considerable a reduction in the temperature of the enormous mass which lies below 1000 fathoms in the Atlantic basin; subject as this must be to continual elevation by the surface-action of the sun on its southern portion. And as the few reliable observations on deep-sea temperatures under the equator indicate that even there a temperature not much above 32° prevails, it seems probable that part of the cooling effect is due to the extension of a flow of frigid water from the Antarctic Pole, even north of the tropic of Cancer. Of such an extension there is evidence in the temperature-soundings recently taken in H.M.S. "Hydra" between Aden and Bombay, where a temperature of 36·5° was observed at a depth of 1800 fathoms. Here the cooling influence could scarcely have been derived from any other source than the Antarctic area.

The unrestricted communication which exists between the Antarctic area and the great Southern Ocean basins, would involve, if the doctrine of a general Oceanic Circulation be admitted, a much more considerable interchange of waters between the Antarctic and Equatorial areas, than is possible in the Northern hemisphere. And of such a free interchange there seems adequate evidence; for it is well known to navigators that there is a perceptible "set" of warm surface-water in all the Southern oceans towards the Antarctic Pole; this "set" being so decided in one part of the Southern

Indian Ocean, as to be compared by Captain Maury to the Gulf Stream of the North Atlantic.* Conversely, it would appear from the application of the necessary pressure-correction to the temperatures taken in Sir James Ross's Antarctic Expedition, the voyage of the "Venus," etc., at depths greater than 1000 fathoms, that the bottom-temperature of the deepest parts of the Southern oceanic basin really approaches the freezing-point, or is even below it. And if the temperature of the deeper portion of the *North* Pacific Ocean should be found to exhibit a depression at all corresponding to that of the North Atlantic, it must be attributed entirely to the extension of this Antarctic flow; since the depth of Behring's Strait, as well as its breadth, is so small as to permit no body of Arctic water to issue through that channel.

That such a general Circulation (modified, of course, by local conditions) is a physical necessity, must be obvious to every one who scientifically considers the results that must happen whenever an extensive body of water is heated in one part and cooled at another. For as water is heated, it becomes continually lighter, and tends to spread itself over the surface; whilst, as it is cooled, it becomes continually heavier,† and tends to spread itself over the bottom. It is on this principle that the hot-water apparatus for warming the interior of our buildings is constructed. The water heated in the boiler passes out from its upper part, and, in virtue of its comparative lightness, rises through the system of pipes which ascends from it; but when cooled by its circulation through these, in the course of which its heat is imparted to the air of the building, it becomes heavier, and gravitates back through the descending portion of the system, to the lower part of the boiler, to renew the same circulation when again heated.—But the great oceanic circulation may be more nearly imitated by a simple experiment, which renders the movement of the water perceptible to the eye.‡ A long, but very narrow trough, with plate-glass sides, having been filled with water, a tube into which a steam-jet is conveyed is introduced vertically at one end, whilst a lump of ice is wedged between the sides of the trough at its opposite extremity.

* "Physical Geography of the Sea," §§ 748, 750.

† Sea-water, as was long since ascertained by Despretz, continues to contract uniformly until it freezes; its freezing point being about 27·4° when it is agitated, and about 25·4° if it be kept perfectly still. It is probable that under great pressure its freezing-point is reduced even below the latter standard; but of the amount of this reduction we have at present no certain knowledge.

‡ This experiment, kindly arranged by Dr. Odling, was exhibited at a Lecture lately delivered by the writer at the Royal Institution.

Some red colouring matter mixed with gum, of such viscidity as to be carried along by any movement of the liquid mass without mingling with it, is introduced into the water at the end of the trough warmed by the steam-jet; and a like mixture of a blue colour is introduced at the end cooled by the ice. The latter very speedily sinks to the bottom along the side of the ice-wedge, and then creeps slowly along the floor of the trough towards its warm end, where it rises along the side of the heated tube until it reaches the surface, and then slowly flows back towards the cold extremity. On the other hand, the red liquid passed slowly along the surface in the first instance, from the warm to the cold extremity, then sinks, as the blue had previously done, creeps along the surface of the blue layer covering the bottom of the trough, and then rises (as the blue had previously done) along the side of the heated tube to the surface. Thus a circulation is shown to be maintained in the water of the trough, by the application of heat at one of its extremities, and of cold at the other; the *heated* waters flowing along the *surface* from the warm to the cold end, and the *cooled* water flowing along the *bottom* from the cold to the warm end: just as it is here maintained that Equatorial water streams on the surface towards the Poles, and that Polar water returns along the bottom towards the Equator, if the movement be not interfered with by interposed obstacles, or prevented by antagonistic currents arising from local peculiarities. The course of each movement must be modified, like the Atmospheric circulation, by the Earth's rotation; and a vast mass of observations must be made and compared, before any general scheme of this Oceanic Circulation can be marked out. But it may be pretty certainly affirmed that no satisfactory rationale can be given of those surface-currents of which the knowledge is so important to the Navigator, unless the deep movements of the ocean-waters, which are complementary to them, can be determined. And this determination, it has now been shown, may be made with considerable probability, if not with absolute certainty, by systematic series of Temperature-soundings.

Thus, notwithstanding the apparently profound stillness of the abyssal depths of the Ocean, which ever remain undisturbed by the storms that agitate its surface, an incessant movement is everywhere taking place in them, which exerts a most important moderating influence on what would otherwise be the intolerable heat of the Equatorial and the unbearable cold of the Polar regions, and thus affects the distribution of Animal and Vegetable life, alike on land, in the surface-waters of the sea, and on the bed of the ocean.

In regard to the *composition of sea-waters*, some new facts have been ascertained by the researches made during the "Porcupine" Expedition, which will be hereafter shown to have a most important bearing on the question how Animal life can be sustained at depths far greater than those to which Vegetable life is limited. During each cruise of the "Porcupine," samples of sea-water obtained from various depths, as well as from the surface, at stations far removed from land, were submitted to the Permanganate test, after the method of Prof. W. A. Miller, with an addition suggested by Dr. Angus Smith for the purpose of distinguishing the Organic matter *in a state of decomposition* from that which is only *decompo-sable*; with the result of showing the uniform presence of an appreciable quantity of matter of the latter kind, which, not having passed into a state of decomposition, may be *assimilable* as food by animals,—being, in fact, Protoplasm in a state of extreme dilution. And the careful analyses of larger quantities collected during the third cruise, which have been since made by Dr. Frankland, have fully confirmed these results, by demonstrating the *highly azotized* character of this Organic matter, which presents itself in samples of sea-water taken up at from 500 to 750 fathoms' depth, and at some hundred miles distance from land, in such a proportion that its universal diffusion through the Oceanic waters may be safely predicated.

The sources of this Organic matter must lie in the *surface-life* of Plants and Animals, especially in the neighbourhood of land; every shore—as a rule—being bordered with a fringe, which averages a mile in depth, of olive and red sea-weed, thickly infested with animals of various kinds; and every river also bringing down its contribution. The surface of every marine plant and animal is constantly imparting to the water in which it lives a mucous exudation, as is obvious to every one who keeps an aquarium; and thus the amount poured into the ocean by that great marine meadow, the Sargasso Sea, which extends over three millions of square miles in the middle of the Atlantic, must be enormous. The organic matter thus locally imparted to the ocean-waters will be universally distributed to all regions and all depths, partly by the oceanic circulation just described, and partly by the process of "liquid diffusion," so admirably investigated by the late Professor Graham. It must be continually passing into decomposition, especially where the temperature of the sea-water is elevated; but it will be as continually renewed from the sources just indicated.

The analysis of the *Gases* obtained by boiling samples of sea-

water, collected from the surface and from various depths beneath it, has afforded some most unexpected results. The general average of thirty analyses of *surface*-water gives the following as the percentage proportions:—25·1 Oxygen, 54·2 Nitrogen, 20·7 Carbonic acid. This proportion, however, was subject to great variations, as will be presently shown. As a general rule, the proportion of Oxygen was found to diminish, and that of Carbonic acid to increase, with the depth: the results of analyses of *intermediate* waters giving a percentage of 22·0 Oxygen, 52·8 Nitrogen, and 26·2 Carbonic acid; whilst the results of analyses of *bottom*-waters gave 19·5 Oxygen, 52·6 Nitrogen, and 27·9 Carbonic acid. But *bottom*-water at a comparatively small depth often contained as much Carbonic acid and as little Oxygen as *intermediate* water at much greater depths; and the proportion of Carbonic acid to Oxygen in *bottom*-water was found to bear a much closer relation to the abundance of animal life (especially of the more elevated types), as shown by the dredge, than to its depth. This was very strikingly shown in an instance in which analyses were made of the gases contained in samples of water collected at every 50 fathoms, from 400 fathoms, to the bottom at 862 fathoms, the percentage results being as follows:—

	750 fath.	800 fath.	Bottom, 862 fath.
Oxygen	18·8	17·8	17·2
Nitrogen	49·3	48·5	34·5
Carbonic Acid	31·9	33·7	48·3

The extraordinarily augmented percentage of Carbonic acid in the stratum of water here immediately overlying the sea-bed, was accompanied by a great abundance of Animal life. On the other hand, the lowest percentage of Carbonic acid found in bottom-water —viz., 7·9—was accompanied by a "very bad haul." In several cases in which the depths were nearly the same, the analyst ventured a prediction as to the abundance, or otherwise, of Animal life, from the proportion of Carbonic acid in the bottom-water; and his prediction proved in every instance correct.

It would appear, therefore, that the increase in the proportion of Carbonic acid, and the diminution in that of the Oxygen, in the abyssal waters of the ocean, is due to the respiratory process, which is no less a necessary condition of the existence of animal life on the sea-bed, than is the presence of food-material for its sustenance. And it is further obvious that the continued consumption of Oxygen and liberation of Carbonic acid would soon render the stratum of water immediately above the bottom completely irrespirable—in the absence of any antagonistic process of vegetation—were it not for

the upward diffusion of the Carbonic acid through the intermediate waters *to the surface,* and the *downward* diffusion of Oxygen *from* the surface to the depths below. A continual interchange will take place *at* the surface between the gases of the Sea-water and those of the Atmosphere; and thus the respiration of the abyssal fauna is provided for by a process of diffusion, which may have to operate through *three miles* or more of intervening water.

The varying proportions of Carbonic acid and Oxygen in the *surface*-waters are, doubtless, to be accounted for in part by the differences in the amount and character of the animal life existing beneath; but a comparison of the results of the analyses made during the agitation of the surface by wind, with those made in calm weather, showed so decided a reduction in the proportion of carbonic acid, with an increase in that of oxygen, under the former condition, as almost unequivocally to indicate that superficial disturbance of the sea by atmospheric movement is absolutely necessary for its purification from the noxious effects of animal decomposition. Of this view a most unexpected and remarkable confirmation has been afforded by the following circumstance:—In one of the analyses of Surface-water made during the second Cruise, the percentage of carbonic acid fell as low as 3·3, while that of Oxygen rose as high as 37·1; and, in a like analysis made during the third Cruise, the percentage of Carbonic acid was 5·6, while that of Oxygen was 45·3. As the results of every other analysis of surface-water were in marked contrast to these, it became a question whether they should not be thrown out as erroneous; until it was recollected that, whilst the samples of surface-water had been generally taken up from the *bow* of the vessel, they had been drawn in these two instances from *abaft the paddles,* and had thus been subjected to such a violent agitation in contact with the atmospere as would pre-eminently favour their thorough aëration.

Hence, then, it may be affirmed that every disturbance of the Ocean-surface by Atmospheric movement, from the gentlest ripple to the most tremendous storm-wave, contributes, in proportion to its amount, to the maintenance of Animal life in its abyssal depths—doing, in fact, for the aëration of the fluids of their inhabitants, just what is done by the heaving and falling of the walls of our own chest for the aëration of the blood which courses through our lungs. A perpetual calm would be as fatal to their continued existence, as the forcible stoppage of all respiratory movement would be to our own. And thus universal stagnation would become universal death.

DEMONISM AND CONVULSIONISM.

BY HENRY WHITE, PH.D.

In proportion as the old faith in witchcraft and magic died away, social superstitions took a new form. Both witches and bewitched became fewer in number: the latter being for the most part women, who, instead of suffering at the stake as in times of yore, were pitied and regarded as involuntary victims of the devils who had taken possession of their bodies. We hear no more of the witches' sabbath, of metamorphoses into cats and frogs, of the evil eye that withered all it fell upon. The case of Louis Gaufridi, a priest of Marseilles, may be regarded as the point of transition between the two contagions. The Ursuline nuns of Aix fancied they were possessed by devils, and accused the unhappy man of not only causing their demonopathy, but of having committed crimes that none but maniacs could have invented. Accusations of such a nature could have but one termination in the early part of the seventeenth century, and Gaufridi's own confession having removed whatever scruples the judges might have felt, he was burnt alive at Aix in 1611.

The story of his trial and execution spread through France and reached a convent at Loudon in Poitou, also occupied by nuns of the Ursuline order, who caught the superstitious contagion. Their supposed possession would have excited little or no interest, but for the charge brought against Urbain Grandier of demonising them by means of a compact entered into with Satan. Grandier was incumbent of St. Peter's at Loudon, and a prebendary of the Holy Cross; a good preacher, a man of the world, handsome, and engaging in manners, but unfortunate in raising up many enemies. As he had never entered the Ursuline convent, or had any communication with its inmates, it is curious that the holy sisters should have accused him; but their superior was intimate with his enemies, and his reputation (good or evil) for gallantry as well as for eloquence had penetrated the walls of the cloister.

The exorcists were soon hard at work to expel the devil, but his name was legion, one sister naming seven who had taken possession of her, and they did not easily leave their pleasant quarters, for if they were turned out one day they returned the next. One morning a cat came down the chimney; it was declared to be the devil that had been expelled from the body of the superior. Poor puss was hunted, caught, and placed on the superior's bed, where an exorcist

made the sign of the cross over the beast, and gravely poured out a torrent of solemn adjurations. At last somebody found out that it was only the convent cat!

If the devils of Loudon were stupid creatures, the monks and exorcists were stupider still. The townspeople, owing, perhaps, to the leaven of Protestantism with which they were tainted, petitioned the bishop of the diocese, the parliament of Paris, and the crown, for a fair and open investigation; but Richelieu, who had a grudge against Grandier, and who caught at this opportunity of paying off an old score, was too strong for them. Had it not been for this private animosity, and the hatred felt by the priests at the independent spirit of the accused man, the case must have broken down under its many absurdities. On two occasions the devils were required to say where Urbain Grandier was at that particular moment, and on both occasions (as might have been expected) the devils were wrong. Another time the superior was asked, why she had not answered on a previous day, "Because (replied the sarcastic devil, who spoke for her) I was busy taking the soul of lawyer Le Proust to hell." It turned out, on inquiry, that there was no lawyer of that name, which was a great mistake, considering there were so many rascally lawyers in those days to choose from. Asmodeus, who seems to have taken up his residence in her body, promised to raise it two feet from the ground; Eazas, another devil, boasted that he would perform the same feat with the body of La Nogeret, another sister; and Cerberus, not to be outdone, declared he would lift his nun four feet into the air. They were called upon to fulfil their promises, and the superior rose up high enough to satisfy the imagination of the most credulous, when a sceptic, venturing to lift the edge of her dress, showed one of her feet resting on the ground. After this, the other two devils refused to keep their promise. Beherit undertook to make amends for this failure by taking the *calotte* off the head of Laubardemont, the chief commissioner, and keeping it suspended in the air during a *miserere*. But two graceless, unbelieving spectators, suspecting a trick, went up to the roof of the church and there found a knavish confederate with a fish-hook fastened to the end of a horse-hair line, which was to be let down through a hole above the choir.

But nothing discouraged the stupid exorcists, the chief of whom, Father Lactantius, announced that three out of the seven devils who had taken up their abode in the superior's body, would leave it on the 20th May, and would testify their departure by three wounds on her left side, and three corresponding rents in her

chemise, petticoat, and dress. After the usual conjurations, the devils departed, but the doctors, who were present as a sort of jury, could find only three slight scratches (as of a finger nail), while the dress was torn in two places, and the chemise and petticoat not at all! The next day, Balaam, one of the four left behind, said that this had been done in order to harden the hearts of the unbelievers!

It had been affirmed that six strong men could not restrain the movements of the possessed superior; but when a sceptical doctor, named Duncan, came forward to test this strange exhibition of muscular power, the woman could do nothing, in spite of the orders of the exorcist. "Let go her arm," shouted Lactantius, "how can she have convulsions while you hold her." "If he is a devil, he ought to be stronger than I am." "Fine logic! a disembodied devil is stronger than you; but being in the nun's weak frame, he cannot resist you, for his actions are proportionate to the strength of the body in which he is domiciled."

In the ceremonies practised to expel the unclean spirits everything was arranged to produce a strong dramatic effect. The possessed person was taken into the choir, and placed upon a couch. Mass was sung, holy water sprinkled about in abundance, the air was filled with the heavy perfume of incense, and then, the curtain being drawn aside which separated the choir from the crowded nave, the exorcists began their holy work. The devil was called upon to tell his name, to say whose agent he was, and to answer any other questions that the priest might choose to set him. This service was in Latin, the language of the Roman Church, and the replies were made in the same language, though very often in exceedingly bad grammar. Though the devil was properly supposed to understand all tongues, this was only an ecclesiastical theory, for he generally broke down when the exorcist or any of the people about put any question that was not to be found in the ritual. In Grandier's case it was proposed to interrogate the devils in Greek, when the patient replied: "You know it was one of the conditions of our *pact* that I should not answer in Greek." These pacts were not the lawyer-like parchment documents which men like Faust and others signed with their blood when they sold themselves to the devil. At Loudon, one of these pacts was described as a bunch of roses thrown over the wall into the convent garden; another was a sort of bolus made of the "heart of an infant, killed at a witches' sabbath, the ashes of a burnt consecrated wafer, blood, and other substances still filthier." One of this nature was vomited up by Leviathan.

Asmodeus was satisfied with a simpler mixture of orange and lemon pips. When these were burnt, the patients were thrown into terrible convulsions; uttering the most piercing screams, they tossed and threw themselves about in such distortions as to horrify the spectators. Bedlam broke loose would give but a feeble notion of what occasionally took place in the Ursuline convent. The end of the matter was the condemnation of Grandier, who after suffering the torture of "the boot," was burnt alive on the 18th August, 1634, only one year before the foundation of the celebrated French Academy. The diabolical carnival did not cease with Grandier's death, but continued for several years after, until the withdrawal of certain pecuniary allowances made exorcism a losing trade.

It is curious to trace the history of some of Urbain Grandier's persecutors. Father Lactantius, a Capuchin monk, who kindled the fire, died on the 18th September, "a prey to the evil spirits whom he had expelled from the body of the superior." The superstitious remembered how with almost his last breath, Grandier had summoned him to appear before God within a month. Another Capuchin, Father Tranquillus, of Saint Remi, died with all the signs of diabolical possession. Mannouri, a surgeon, who had examined Urbain's body in search of "devil's marks," which, of course, he found, was haunted day and night by his victim, and died of the terror caused by such an unpleasant visitation. Surin, another exorcist, became in his turn "possessed of devils," and continued so for twenty years. Many of the witnesses against Grandier came to a miserable end. It would offend the common sense of the present day to call these results "a divine judgment;" the power of a disordered imagination is quite sufficient to account for them, even if we accept the stories as literally true.

Some curious psychological facts turned up during the Loudon case. Three women of good repute came forward and swore that by a mere glance of the eye, or a touch of his hand, Grandier had filled them with a strong amorous passion for him. Fourteen nuns swore that they had seen him day and night in the convent, and that he had solicited them improperly. Two even made statements that we dare not copy. Such confessions were regarded by the exorcists as indisputable evidence of sorcery; but men of science now-a-days know well how to account for these sensual hallucinations. Though fortunately rare, they are numerous enough to find a place in medical works; while they throw a curious light upon certain recent proceedings in the Divorce Court.

Another curious circumstance was noted in the course of the Loudon investigations, which was considered an additional proof of demoniacal possession. The patient sometimes lost all voluntary power over her limbs, and could only move them as the exorcist directed. And further than this, the demoniac is said to have had the power of divining the thoughts of others. Three days after Grandier's execution, Elizabeth Blanchard, a lay sister of the Ursulines' convent, was grievously tormented by one of her six devils, and by way of testing the power of the evil spirit two monks standing some distance from the demoniac, agreed in whispers as to a certain movement which she should execute during an act of adoration commanded by the exorcist. She made the movement, which clearly showed that the demons knew what took place in secret! In May, 1635, and in the presence of Gaston of Orleans, brother of Louis XIII., the same woman was exorcised by a Capuchin monk, and there was a similar manifestation of this thought-reading power. At the same *séance* the exorcist "benumbed the demoniac and rendered her pliable as a slip of lead" (*lame de plomb*). He bent her body backwards and forwards, then from side to side, until her head almost touched the floor, and she kept in this posture until it was changed for her. There will be nothing strange in this to persons who have witnessed similar manifestations by patients in the mesmeric state. The exorcists may have been the unconscious possessors of mesmeric power. In the presence of Gaston, the exorcist said to Elizabeth Blanchard, "*Obedias ad mentem principis.*" She went and kissed the hand of the prince, who declared that she had correctly interpreted his thoughts. On the same occasion, another nun was (mentally) ordered to go into the garden and bring back five rose leaves. Twice she disobeyed the order, but the third time (*sub pœna maledictionis*) she came back with a branch from which she had plucked all the leaves beyond the number required. As we glance over this brief history of the Loudon tragedy we come to the conclusion of the doctor in the case of Martha Brossier (1599): "*Multa ficta, pauca a morbo, nihil a spiritu.*" He was farther advanced than his brethren of the faculty of Montpellier, who accepted the phenomena of possession as readily as the lawyers, monks, and clergy.

In the history of the Convulsionists of St. Médard, we meet with a repetition of nearly all the phenomena of the nuns of Loudon; but the contortions in the one case were ascribed to the devil, in the other to a holy saint. The scene of the later superstition was a cemetery in Paris, where a crazy fanatic, François de Pâris, had

been buried. François, even when a boy, had shown a strong disposition for the ecclesiastical life, and at twenty-one he entered a Jansenist monastery. At the age of twenty-eight he was made a sub-deacon, and then began a course of life that would be ludicrous, if it were not for the manifest sincerity of the man. He fasted and scourged himself, dressed in sackcloth, lived in a hut as foul as a pigsty, rarely washed, wore shoes that beggars rejected, and went half naked. In fact there was no mortification that he did not practice. He died in May, 1727, at the age of thirty-seven, a religious monomaniac, and was buried in the churchyard of St. Médard in Paris, when the miracles began almost immediately. An old-clothes man had long suffered from ulcers in his leg, which the mediciners of that day could not cure. At last a worthy button-maker advised him to go to the deacon's grave. He crawled thither, paid the fees, repeated the prayers, and carried back a little piece of the saint's bedstead, which he was to apply to his leg. In ten days he was able to walk without help.

The game went on merrily now; but the number of miracles increased wonderfully after a monument had been erected over the grave of the defunct deacon. This monument was a slab of black marble supported by four short columns about a foot above the level of the soil. A young woman, age unknown, was the first to test the curative powers of this new arrangement. She was suffering from paralysis, and her confessor, a Jansenist, told her of the miraculous cures that had been worked at the deacon's grave. Her first and second visit were ineffectual, at the third she was able to kneel, but complete recovery (she was told) depended upon her being able to crawl under the monument. After many unsuccessful efforts she passed her head through the interval, and the disorder left her. She jumped up, made a *pirouette*, and skipped away so gaily that the friend who had aided her to reach the burial ground could hardly keep up with her. A damsel named La Loé, suffering from a blow which had caused her breast to swell to a frightful size, as also her shoulder and arm, was cured by the application to the afflicted part of a little bag filled with wool from the deacon's mattress and some chips of his bedstead. In four and twenty hours she was thoroughly healed. The Jesuits did not deny these cures, but declared them to be the work of the devil, to which the Jansenists replied that the fact of the miracles proved their divine origin and the orthodoxy of the deacon. But as the latter sect had been condemned by a papal bull, it would never do to let them defy the pope with these supernatural weapons, and the civil power was invoked against

them. A Jansenist bishop was deposed, and two hundred Jansenist doctors of the Sorbonne were exiled. In other respects the persecution was equally severe, so that now or never was the time for heaven to interfere to preserve the good cause. Accordingly the miracles took another and a singular form.

The first to inaugurate the new series of supernatural exploits was one Aimée Pivert, a mature virgin of forty-two, who for two years had been unable to walk without crutches. She had heard of the miracles of St. Médard's, and crawled thither with great difficulty. Nine days she repeated her painful pilgrimage, her sufferings at the tomb being on each occasion very intense; at the last visit she rubbed her right side with some earth from the grave, and rose up quite healed, leaving her crutches behind her to testify to the cure. This was the first instance in which the convulsions were observed. The second was that of Marie Madeleine Bridan, who was paralyzed, half blind, and suffering from erysipelas and other evils. On the ninth day she was seized with strong convulsions, and for an hour and a half tossed and tumbled about so violently that it required three or four persons to prevent her falling off the marble slab. During twenty-four days she went through the same trials, which were repeated with increasing violence every time she drank water in which some of the earth from the deacon's grave had been placed! Marie Madeleine was cured, as were others, by means of the same violent remedy. The last case we shall notice was that of Marie Anne Vapereau, who had been discharged as incurable from the hospital at Orleans. She suffered from a most disagreeable complication of disorders: swellings in the legs, hernia, paralysis of the bladder, a fistula in the right eye, caries in the nose, and so on. The regular number of days having elapsed, the spirit of the holy man got hold of her. Her head became confused, her arms and legs were convulsed; even in the street, she was saved with difficulty from falling to the ground. The pious women with whom she lodged had a hard time of it—indoors and out, in parlour or kitchen, she was always tumbling about. It was a hard job to keep her out of the fire. But relief came at last, her maladies disappeared, and convulsionism became the fashion.

The scenes in the St. Médard churchyard remind one of certain epidemics of the Middle Ages, particularly of the dance of Saint Guy (*chorea Sancti Viti*). This convulsive action was described by Plater, in 1614, as a "*morbus singularis*," and he tells how a woman affected by it kept dancing day and night continuously for a month, only stopping to change her worn-out shoes, or when she fell asleep.

Although dancing was the principal symptom of this new disease, it was not the only one; convulsions and maniacal laughter were not uncommon. There could be no doubt of its source: "*sine dubio a dæmone immissus fuerit,*" says Sennert. The experimenters of the eighteenth century improved upon the lessons of the past. Some fell to the ground and tossed about in epileptic fits; others swallowed flint stones, pieces of glass, and live coals. Women were seen walking on their heads without the slightest regard to decency; others lay upon the ground, calling upon the spectators to beat them upon the belly with stout clubs, young men being especially desirable for the administration of this "succour," as it was technically called. There seems to have been a large amount of sexual feeling mixed up with these displays. Young women in their convulsive state would pass their heads between the legs of young men, and rising up, carry them about astride on their shoulders; or a man or woman would be seen with arms and legs outstretched as wide as possible, so as to form a cross. (This manifestation had been observed among the nuns of Loudon.) The whole was mixed up with an uproar of groans and screams, the cry of cats, and songs not always decent; while the Abbé Bécherand would turn his daily summersault on the slab of the deacon's tomb. After these outrageous performances had lasted a month, the cemetery was closed by an order of the king, which a wit of the day immortalized in these two lines:

De par le roi défense à Dieu
De faire miracle en ce lieu.

But shut out of one place, the convulsionists went to another and continued their meetings in churches and private houses. Naturally the manifestations became more startling, as the followers of Deacon Pâris imagined themselves the victims of state persecution. Some of the conversions were very singular. The Chevalier Folard, a soldier of good repute, known in literature by his "Commentary on Polybius," was cured in a few days of the infirmities contracted during his military career; but the miracle did not stop here. Folard was never free from convulsions, and his case is the more singular, as there can be no doubt of his good faith. After his conversion he resigned all literary pursuits, and passed his time in praying, reading books of devotion, and attending convulsion meetings. Whenever he came to the *Magnificat*, in the Evening Service, he went into convulsions, fell on the floor, and there lay with outstretched arms, continuing the prayers in a peculiar singing manner, weeping, and winding up by a babble of words that nobody

could understand. At times a curious noise would issue *from his ear*, that could be heard in all parts of the room. While his legs were hanging over the arm of a chair, his body would be in constant motion, as if he were attempting summersaults. He could see nothing when he opened his eyes; but when he shut them, all was like bright sunshine. When this convulsive state passed away, he remembered nothing of what had taken place—another similarity to the mesmeric condition.

Fontaine was another of these converts. He was *secrétaire des commandements* to Louis XV., and had taken the side of the court with respect to these manifestations; at a dinner-party, where the convulsionists were much talked of, he was "converted," and in the presence of all the guests began to spin round like a dervish. He asked for a pious book, one was handed to him (it was a Jansenist work), and while turning round, he began to read it aloud. Twice a day these convulsions seized him, and did not quit him until six months after, when he had read through the book given him at the dinner party. The converted Fontaine became a prophet, and foretold the second coming of Elias, the gathering together of the Jews, and the conversion of the infidels. He also became a great ascetic, on one occasion abstaining for eighteen days from all food or drink! This almost killed him, but he had no sooner recovered from the effects of this silly abstinence, than he commenced a fast of forty days, during which he took nothing but a little liquid to allay his thirst.

The widow Thevenet, a respectable *bourgeoise* of Paris, supplied another phase of convulsionism. She was deaf, and hoped to be cured by drinking a little water into which some earth from the deacon's tomb had been sprinkled. After some days her agitations began. At first they were mere nervous terrors and tremblings. She beat herself violently, and jumped about the room regardless of decency. One day she sprang off her bed, leapt so high as almost to touch the ceiling, whirled her arms about, tossed her head, and at last her breasts, escaping from the confinement of her stays, *tournaient d' elles-mêmes et s' entortillaient comme si quelqu'un les eût tordues avec la main*. One night she and a fellow convulsionist were seen dancing stark naked, laughing and throwing their night-caps at each other. Much more of this mad shamelessness is recorded by Calmeil.

The two last phases of convulsionism were the worst: the succour and the martyrdom, in both of which there seems to have been a total suspension of physical sensibility. Certain convulsionists—

they were nearly always women—finding their self-inflicted blows not effectual to give them relief, called on the bystanders to help them. This help or "succour" was *small* or *great*, as the case might require. Sister Scholastica had denounced both kinds of "succour," but she was soon converted from the error of her ways, and invented a new kind of relief. She had herself hung up by the feet and was let fall to the floor head downwards, as if she were a paviour's beetle. It is to be hoped that she was cured of her leprosy and abscess. Another woman, whose body was bent like a bow, and supported by a stick placed under her loins, called out for *Biscuit.* This was not the article made by bakers, but a stone weighing fifty pounds, raised by a rope and pulley to the ceiling, and let fall upon her stomach. She seems to have felt no pain, but kept crying out, *stronger, stronger.* Another girl, whose swollen muscles could not be relieved by the "little succour," was "charitably" beaten with stout oaken clubs, seven or eight inches in circumference at one end, the "succouring brothers" raising the clubs above their heads at each blow, and coming down on the patient with all their might. One is involuntarily reminded of Jack the giant-killer, who was only "tickled" by the blows of the Welsh giant's club on his bed; but then Jack had wisely substituted a log of wood for his own body. Another female convulsionist was beaten on the head with four clubs, then pullod by the arms and legs as if she was to be torn asunder. Three men mounted on her shoulders, she was hung up by the feet, and trampled under foot by fifteen persons at once. Jane Maulet was still more terribly mauled. She was beaten with a rough bar of iron weighing thirty pounds—not on the abdomen but on the pit of the stomach. The succourer struck her so violently that he shook the wall at her back. Far from suffering pain, she found the beating so pleasant that she wanted more: "Oh que cela est bon! oh que cela fait du bien! courage, mon frère, redoublez encore de force, si vous pouvez!" She received one hundred and sixty blows, and the "brother" who inflicted sixty of them, gives us some idea of their force, by telling us that with twenty-five similar blows he broke a hole through the wall.

These curious scenes lasted for ten years, from 1731 to 1741, and were revived after a lapse of eighteen years, when crucifixion became the fashion among these fanatics. At one of the *séances* in 1759, the famous La Condamine was present; he saw a patient who had been crucified twice before, suffer her hands and feet to be fastened to a cross with nails three inches long! Such self-

tortures merely help to show how much pain the human form can bear without wincing. But insensibility to pain is no new phenomenon: Hindoos and maniacs, North American Indians and mesmerised patients, soldiers, sailors, anybody under strong excitement can bear torture from wounds that in other circumstances would be almost unendurable. And there is no excitement so absorbing as that caused by religious fanaticism.

The explanation of the phenomena described above has become easy since the world has lost its belief in demonopathy—taking that word in its broad sense as expressing the influence of supernatural powers on mankind. In times of ignorance men saw the finger of a saint or of a devil in every phenomenon at all out of the common order of things. Just as in the east at the present time lunatics are regarded as inspired by Allah, so in Europe until these hundred years (if not later) the ravings of hysteria and the contortions of epilepsy were ascribed with equal truth to demoniacal influence. If we reject from the stories of the Ursulines of Loudon and the convulsionists of Paris much that is evidently mere trickery and fraud—if we make due allowance for the exaggeration of eye-witnesses prejudiced in favour of supernaturalism—we arrive at a small residuum of phenomena capable of a very simple explanation. There is indeed nothing in the Loudon "possession" that cannot be paralelled in the cases recorded in medical works of persons suffering from hallucinations of various kinds produced by that multiform disease hysteria, or by indigestion, or by that singular nervous state which may be denominated "sympathy." Some striking cases of this nature are mentioned in the twelfth volume of the "Mémoires of the French Academy of Medicine" for 1846. Those who remember the manifestations of the "unknown tongues" some forty years ago, will recognize the similarity (in degree) with some of the scenes in the Loudon convent. What began in fraud was propagated by sympathy by young women who were themselves deceived. The convulsions of St. Médard originated in a strong unregulated imagination. We know that imagination can cause diseases as well as cure them. We know that the dance of St. Guy (or St. Vitus) was contagious, just as fear is. If a panic will make the bravest soldiers take to their heels, it is not surprising that a crowd of young women should be thrown into convulsions at the sight of the contortions of one of their number, and at the noise of her screams. There is nothing strange in all this, until the priest comes forward and tells us that the phenomena are the work of the devil or of some dirty Jansenist saint. The "succour" of the convulsionists is often

paralleled by the common street-juggler, who will toss a large stone high into the air, and catch it on his forehead, where it is smashed into little bits. The man who has broken a kitchen-poker across his arm, or seen the feat done by others, can feel no surprise at the violent blows suffered by the patients of Deacon Pâris. We have seen a female juggler, supporting her head on one stool and her feet on another, suffer a horse-shoe to be made, and a bar of iron beaten out with two sledge-hammers on an anvil placed on her stomach. How some of the "succour" tricks were performed, it may be difficult to say, because of the imperfect nature of the descriptions; but tricks they were, and we may be very sure that there was nothing in the severest of them, that has not been in a greater or less degree repeated before a crowd of gaping rustics at a country fair.

ON ZYMOTICS.

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From the time of Hippocrates until a comparatively recent date, all the efforts of medical science were devoted to one aim—the discovery of a means of curing disease, to find a something, which, when employed by one ill of a fever, or an inflammation, should stop that fever or inflammation in its full career, and rapidly restore the patient to his usual health and strength. This was the great object of all physicians up to the end of the last century; they sometimes imagined that they had discovered the specific, whether in blood-letting, or some other mode of treatment; but they were always compelled, in the end, to acknowledge, after long trial, that their specific had failed to cure; they were as unsuccessful, and as likely to be unsuccessful, as was the alchemist in his attempt to transmute the metals, or to discover the elixir of life. But a great change has now passed over the aim and object of the medical art; the cure of disease, once set above all others in importance, has sunk to a secondary place, and the first aim of medicine is now a days to *prevent* disease. This great revolution, as important to medical science as the observations of Priestley were to chemistry, or Bacon's philosophical reform to the laws of thought, was brought about by Jenner's great discovery of the protection conveyed by vaccination against that frightful scourge, small pox. It was this that turned

the whole stream of medical energy into the channel in which it now runs; till then, men had been content to accept disease as an inevitable affliction; they now began to understand that it was possible to prevent it, and from that time, the energies of all the busy workers in every university and school of medicine in Europe have been devoted to one aim—the extinction of disease, and, as an essential means to this end, the study of disease in every one of its subtle, many-sided aspects.

Let it, then, be reiterated that the first aim of medicine is to prevent disease. The public have not yet learnt this, they still imagine that the only business of the doctor is to cure them when they are ill. In newspapers, the writers often blame the doctors for not having found out a cure for such and such a complaint, just then prevalent; they demand to be told, for example, the use of an art which cannot cure either the cattle-plague or the cholera. The answer to this is, that no one now a days expects to find out a cure for these diseases; from what we know of their natural history, it seems probable that there never will be found out a cure. Further, much more could be done by what we even now know of the methods by which they can be suppressed, than if we could find out a method for curing one half of the cases attacked. The popular ignorance on this subject was never brought out so completely as in the year of the cattle plague, when the public for several months refused to listen to the only scientific and rational plan for its suppression, offered by Mr. Gamgee, but adopted instead the wildest and most absurd methods for its cure, suggested by persons who had not the slightest pretensions to knowledge on the subject. Had Mr. Gamgee's advice been acted upon in the early stage of the plague, the country could be now many millions richer than it is. It is to be hoped that the readers of the STUDENT will do their best to dispel the unscientific notions, prevalent amongst even well-educated people, as to the aim of medicine, for it is only by a wide diffusion of knowledge on this subject, that any attempt to check the progress of the immense amount of disease entirely preventable, raging in this country, whether by state interference, or individual action, can be successful.

On referring to the Registrar-General's reports for the last ten years, we find that in England and Wales about five hundred thousand people die every year; of which five hundred thousand, one hundred thousand die of zymotic diseases; that is, twenty out of every hundred people who die, die, usually at an early age, of disease which can, and ought to be, prevented.

These so-called zymotic diseases have been chosen for the subject of this article, because they best illustrate what has been said about the prevention and the cure of disease. No approach to any means of curing them has been discovered; but of all the complaints known, they are the most easily preventable; in no other group of diseases is there a something which can almost be handled, which is the essence of the complaint, without which the complaint would not exist. It is to the destruction of this substance that our efforts in the suppression of these diseases are directed, for could all the contagious material in the universe be destroyed, these diseases would cease to have a place in the nosology. A knowledge of their natural history is necessary to a comprehension of the means to be employed in preventing their occurrence, and a slight sketch will therefore be given of their course when attacking the individual, and of the circumstances under which they spread.

The diseases called zymotic—a name which is bad, because based upon a false theory, but which has become sanctioned from long use—are, in systematic medicine, known as the acute specific diseases; acute, because always of short duration, tending spontaneously to cease at a fixed date from the attack, and never extending over months and years, like chronic diseases; specific, because they are accompanied by a process peculiar to each one of the group, a process quite *sui generis*, and unknown in the course of other acute complaints. Amongst them stand measles, scarlet fever, hooping cough, diphtheria, mumps, typhoid fever, typhus fever, and small-pox. Measles may be regarded as a type of this class of complaints. It has a greater tendency to spare the life of the individual than most of the others; it is very widely distributed, and few people reach adult age without having suffered from an attack. The history of the complaint, and of those associated to it, is, therefore, personally interesting to almost every one.

The acute specific diseases are distinguished by five peculiarities. 1. They occur but once in the life of the individual, who thenceforth is secured from a second attack. 2. They always result from contagion or infection, never arising *de novo*, from exposure to cold, or other causes of disease, as bronchitis or rheumatism does. 3. There is always an interval, longer or shorter, between the date when the individual receives the contagion into his system, and the date when he first begins to feel ill. 4. There is an interval between the first feelings of illness and the first appearance of the specific process, the rash on the skin, or the sore throat. 5. The specific disease always runs a sharp well-defined course

lasting a certain number of days, and tending to end in the recovery of the patient, at the termination of the specific process. These five characters will now be considered more in detail.

Each disease, as a general rule, and only as a general rule, occurs but once during life. Every mother, for example, knows that when her child has had the measles, or the hooping cough, it will be secure against a second attack. It not unfrequently happens, however, that a second attack of measles or small-pox occurs; in these cases, especially the latter, the complaint runs a much less severe course than in the first. In the great majority of individuals, the protection afforded by one of this group of diseases against its recurrence is complete. This immunity from a second attack is one of the most curious problems in medicine. Everyone knows how a part, once affected with a complaint, is liable to a return on the slightest causes, *e. g.* a common cold, or a sore throat. With the acute specific, or zymotic diseases, the case is exactly the reverse, and at the present moment there is of this no satisfactory explanation whatever. Many years ago, a theory was propounded, referring the whole of the phenomena of these complaints to a species of fermentation. When the germs of the yeast plant are introduced into a solution of sugar in water kept at a suitable temperature, the yeast plant converts the sugar into two new compounds quite different from the original sugar, alcohol and carbonic acid. Nearly the same changes were believed to occur in the human body. Every child was supposed to be born with a variety of fermentable substances in his blood, in number equal, and corresponding, to every one of the zymotic diseases. These fermentable substances meeting with the germs of disease, were acted on by them exactly as the sugar is acted on by the yeast plant; such a process going on in the body would naturally enough cause a feeling of illness; the fermentation was supposed to account for the fever, while the eruption on the skin was the means by which the products of the fermentation were thrown off. If the fermentation were completed, and the whole of the fermentable substance changed into new compounds, that accounted for the subsequent immunity of the patient, for, the whole of the fermentable substance, which was the food and sustenance of the disease, having been destroyed, no further attack could possibly occur. But if the fermentation had been incomplete, and the whole of the fermentable substance not destroyed, then the patient was still liable to a second attack, for he retained in his blood what might at any time be set off into new activity, if again encountered by the germs of the

disease, and thus a second attack might occur. The theory explains a good many of the facts, but it demands too great a concession at the outset. Few will be disposed to admit the presence in the blood of nearly twenty distinct and separate substances, which exist only to serve as a nidus for the specific ferment, and to be a source of injury to the individual. The name zymotic (ζύμη, leaven) still continues to be applied to this group of complaints, on the principle of *lucus a non lucendo,* chiefly because they have been rendered familiar to the public, in the Registrar-General's reports, under this title.

Another striking feature in the natural history of these disorders is that they are never known to arise spontaneously, as other complaints do; but their origin is always due to a certain *contagious matter.* There is no properly authenticated case on record of a person having suffered from an acute specific disease without having been in some way infected from another person suffering from the same complaint. Recent discoveries seem to suggest that this contagious matter is a vegetable growth—a fungus. Some observers, especially in Germany, aver that they have been enabled to detect under the microscope the little plant which is the cause of cholera; others assert, that certain fungi found in mouldy straw will produce measles in less than forty-eight hours after inoculation. Sir Henry Holland has thrown out the idea that these diseases are produced by clouds of animalcules passing over a country; and he considers that the way in which an epidemic or contagious fever advances, supports this view. The zymotic theory has just been stated. These opinions are introduced only to show how little is really known about the nature or composition of the contagious material. Of its existence, there can be no doubt, but of its form, whether animal or vegetable, whether a ferment, or simply some organic chemical combination, nothing is known. With regard to the mode in which this contagious material is conveyed to individuals: it is a common idea that it is carried through the air, or even that it is produced *de novo* where there are bad smells, defective drainage, and in low, damp situations. The notion that the air carries the contagious matter is singularly devoid of any support from the manner in which these complaints usually spread. When, for example, an infectious disease passes from one place to another, it moves along the line of traffic, not in the direction of the wind, but along the course taken by travellers; when a contagious disease leaves a continent for an island, it always makes its first appearance in a sea-port. In fact,

the contagious material seems capable of being carried but a very short distance, probably only a few feet, by the movement of the air; one of the best means of disinfection is to send a free current of air through the room or space, fresh air seeming to have the power of destroying or weakening, perhaps by dilution, the contagious material. Nor is there any evidence to prove that bad smells, etc., produce these specific diseases anew. There is no doubt that defective drainage, and crowding of people together, predispose to the reception of these specific complaints, and are themselves the direct causes of many and serious illnesses, but bad sanitary arrangements in a house or a town never generate these epidemic disorders, they must be brought from without, and then, under these bad sanitary conditions, they spread with frightful rapidity, and cause immense mortality. An instance in proof of this may be found in the hygienic condition of England before the time when the cholera first visited us. Then the sanitary condition was probably as bad as could be, yet the cholera did not exist until it was brought over from the continent of Europe, when it spread rapidly and decimated the country.

What, then, is the way in which the contagious matter is conveyed? Chiefly by emanations from the sick man. The clothes which he has worn, the bed on which he has lain, the furniture, carpets, and curtains of the room in which he has lived, all become the recipients of the contagious material, retaining it for months, or carrying it with them for miles. The contagious matter of small pox and scarlet fever is particularly persistent. Clothes which had belonged to some one suffering from small-pox, and been laid by for months, have passed on the complaint to those who have had the misfortune to handle them. The poison of scarlatina is most difficult to eradicate, chiefly from the desquamation or peeling off of the skin, which occurs when the malady is passing away, and which is the chief medium for the dissemination of the contagious matter; the skin or cuticle comes off in very fine powder, which is extremely light, and penetrates into every corner of the room which dust can reach, accumulating on the cornice of the door, on the shelves of book-cases, or projecting parts of picture frames. The clothes which the sick man has worn are a frequent medium of contagion; it has been noticed that they have been sent for miles to people who were quite ignorant of the fact that they came from an infected place, and yet have communicated the contagion. Woollen clothes retain the infectious material much more than cotton, for the obvious reason that wool, from its structure, is much more

likely to absorb the poison than cotton. Black clothing also retains the contagious material for a longer time than white; this fact is quite unexplained. It was first noticed at the military hospitals in Vienna, where it was found that when a soldier with a white uniform had recovered from an infectious disease, and was sent back to the barracks, fewer admissions into the hospital were made of his fellow-soldiers, suffering from the same disease, than when the patient's uniform had been of a dark colour.

The bed clothes and bedding, from the wool and hair which, they contain, offer a large surface for the reception and retention of the contagious material. The carpets and curtains are frequently sources of contagion, because seldom disturbed. Drinking-water also conveys the infection; the emanations from the sick man, the water in which he has washed, etc., are too often thrown carelessly away, and unless properly disinfected, the contagious material may find its way into wells and cisterns, and thus spread the disease. Typhoid fever, which destroys on an averge ten thousand people in the prime of life, every year in England, is almost solely propagated by the drinking water, as it is very slightly contagious to those who nurse or tend the sufferers. Dr. Snow in his work "*On the Mode of Communication of Cholera*," has proved most conclusively that cholera is chiefly communicated by the drinking water, and but seldom through the ordinary means of infection. To conclude this subject, it must not be forgotten that each specific disease has its own specific germ. The poison of small-pox will not produce measles, but only small-pox; and an attack of small-pox offers no protection whatever against measles.

When the contagious matter meets with an individual in a condition favourable to the production of the disease (for, like the seed, the contagious matter must be placed in a fit soil before it can germinate), the individual thus attacked does not at once show symptoms of illness, nor indeed does he know that he is going to be ill, but there is always an interval, usually many days, between the reception of the poison, and the first feeling of malaise. This stage is called the *stage of incubation;* in which the disorder is latent within the patient, for there are no signs or symptoms by which it can be known that he retains within him the seeds of severe illness; he goes about his ordinary occupations, and feels quite in his usual health. This period of incubation varies in different illnesses; in small-pox and measles it is twelve or fourteen days; in scarlet fever it lasts from five to twelve days, never being less than five, or more than twelve, in duration. The knowledge

of this fact may often be of practical use; if a child have been, by chance, to see another who has taken the measles or scarlet fever, the mother would know that all risk of the infection would be over in about a fortnight from the time of the visit. For this reason it is that travellers are detained so long a time in quarantine, lest any of them might be in the incubative stage of an epidemic.

The end of the stage of incubation is announced when the person begins to feel ill; what is called the *stage of invasion* has arrived, and this is the commencement of the illness properly so called; like the stage of incubation, this has a course of a certain number of days, varying in each disease. In scarlet fever the invasion-stage lasts only twenty-four hours, and is accompanied by feverishness and sore throat; in small pox it lasts forty-eight hours, and there is also a great pain in the back, and the patient feels seriously ill. In measles this stage lasts three days, during which the child is feverish, and its eyes and nose pour out a fluid, which scalds the skin over which it flows. In hooping cough, the stage of invasion lasts nearly a fortnight, during which time the child seems to have only an ordinary severe cough, without anything to announce its specific character. When the complaint is in the stage of invasion, no drug or medicine is known which has the least power to stop the illness from going on further into *the specific stage*, which like the two preceding stages, has a sharply defined duration, beyond which it never lasts, and within which it never terminates, except by the death of the patient. The tendency of this stage is to end, after its specific duration, in the complete recovery of health. In no complaint is this better exemplified than in typhoid fever. Here the specific illness never lasts less than twenty-eight or more than thirty days; during this time the patient is feverish, with a temperature of the body often rising to 105° F., and is delirious and entirely without appetite. If the patient only survive the twenty-eighth or thirtieth day, the fever and delirium go, the temperature of the body falls to the natural standard, 98° F., and the appetite begins to return. This illustrates what was said about the power of curing disease, and the importance of an intimate acquaintance with its natural history. Here the physician is aware that he cannot cure, but at the same time he knows that, if he can keep his patient alive over a certain day, the patient will recover; the only endeavour of the physician in this case is, then, simply to prolong life, to enable the patient to live over the critical day, and thus by simply endeavouring to *prolong* life, the physician often succeeds in *saving* life.

In this specific stage there are two symptoms, the specific process, and fever. In small-pox and measles, the specific process is the rash on the skin; in scarlatina, the rash on the skin, and the sore throat conjoined; while in diphtheria it is the sore throat alone, which is the specific process. This specific process is the essence of the whole disease, without which the disease could not exist, and the means by which the disease is propagated. The specific process itself is strictly local, never affecting all the tissues of the body generally, but limiting itself to one set of tissues, or to those analogous to it. Thus in small-pox, the local specific process is limited to the skin alone, except when it attacks, in grave cases, the mucous membrane, similar in structure to the skin, of the windpipe and air-tubes of the lungs. In diphtheria, the mucous membranes alone are involved, while in typhoid fever it is the adenoid tissue, which the spleen and some other organs largely contain, that is affected. Fever is a constant accompaniment of the local specific process; and by fever we simply mean that the temperature of the body, as measured by the thermometer, is greater than in health. The natural temperature of the body is 98° F., but in fever it rises above this. The temperature of the body in health is maintained by a constant oxidation or burning of the tissues by the oxygen of the air, brought by the blood from the lungs. In fever, this process of combustion goes on more rapidly, and the tissues are burnt away at a higher rate, and thus an elevation of temperature is produced. A great increase in the products of combustion, which are eliminated from the system, takes place during the fever, or at its termination. This process of increased combustion readily explains the rapid emaciation which occurs in fevers. The great debility of the patient depends upon the exhaustion produced by the high temperature. According to Joule's law, every degree of increased temperature represents a certain amount of mechanical exertion. The Rev. Professor Haughton says: "The work due to animal heat would lift the body through a vertical height of eight miles per day; and it thus appears that an additional amount of work, equivalent to the body lifted through one mile per day, is spent in maintaining its temperature at fever heat. If you could place your fever patient at the bottom of a mine, twice the depth of the deepest mine in the duchy of Cornwall, and compel the wretched sufferer to climb its ladders into the open air, you would subject him to less torture from muscular exertion, than that which he undergoes at the hand of nature, as he lies before you, helpless, tossing, and delirious on his fever couch."

Both the local specific process, and the fever, have a tendency to terminate in the restoration of the sufferer to health, without any intervention of the medical art. But at the termination of these conditions a state of health, often wretchedly below par, is left behind. Scarlet fever frequently destroys the drum of the ear, by extension of the sore throat backwards into the Eustachian tube, and there sets up an ulceration by which the patient's life is in constant jeopardy; at any time, too, from the fading of the rash until a month afterwards, that fatal form of dropsy, called scarlatinal dropsy, may supervene on the slightest exposure to cold. Measles, chicken pox, and whooping cough, very slight in themselves, leave behind a predisposition to a most fatal complaint, the deposit of tubercles in every part of the body. In grown up people, the brunt of the disease usually falls upon the lungs, and it is then called consumption; but in children the disease is spread more generally throughout the system, the brain and other organs suffering quite as much as the lungs. This disposition to tubercle arises after these three diseases without any previous hereditary taint or inclination whatever. The zymotic diseases, then, are not the harmless ailments which the public think to be, but even the mildest may leave behind the seeds of a malady which, sooner or later, will destroy life.

The circumstances under which zymotic diseases are enabled to spread are the following. First of all, the zymotic principle itself must be present, next, a condition of the atmosphere or of the surroundings, favourable to the spread of disease; small-pox and scarlatina are always present in England, yet it is only occasionally that the sporadic cases multiply so greatly as to become epidemic. Thirdly, a medium for the conveyance of the contagious matter to the individual or some part of him, where it can easily enter his blood; it seems probable that most of the zymotic poisons enter by the mouth. Lastly, an individual in a state fit to receive the germ of the malady, and allow it to multiply.

Knowing that these four conditions are necessary for the spread of these contagious diseases, the means at our disposal for their prevention will be shortly alluded to. With regard to the zymotic substance, the agent which most effectively destroys it, is heat. In Egypt, the spread of the plague is always arrested after St. John's day, from the intense heat which then arises. A temperature of 120° F. will destroy the contagious material contained in clothes, papers, etc., thus most conveniently disinfected, the most delicate fabrics remaining uninjured after exposure to

so low a temperature. Several chemical agents are said to have the power of altering or changing the composition of the contagious material, so as to render it innocuous. Amongst these are especially to be mentioned carbolic acid, chlorine, and nitrous acid.

The state of the surroundings is very important, but unfortunately little is known of the meteorological changes which accompany an epidemic. A temperature of 32° F. seems to check the spread of some contagious diseases, but the whole of our information on this point is most meagre. One of the surrounding conditions is known to be extremely important—the dilution of the contagious material with fresh air—this is without doubt, the most important agent that we possess in checking the progress of a contagious disease. Free, efficient ventilation of a house will often protect its inmates from infection from without. The media for the conveyance of disease have been spoken of previously. A predisposition on the part of the individual who is exposed to the contagion; for not every one exposed, is infected. Some persons seem quite incapable of receiving the zymotic diseases during the whole of their life; while on the other hand, certain conditions of the system predispose to them; mental anxiety, worry, and trouble of any kind render a person peculiarly liable. So do fear of taking the complaint, a poor state of health at the time, great bodily fatigue and exhausting labour, above all, the fasting state. A person who has not eaten for hours will be far more likely, other conditions being equal, to be infected on exposure to contagion, than one who has just taken a meal of meat and wine. We cannot always control our emotions or secure a tranquil and happy frame of mind; but at the worst, most of us can afford a dinner and a dose of stimulant. After exposure to infection, a glass of sherry, or brandy and water, is said to prevent the complaint from taking root; it would always be well to try this remedy, when a person has been near a source of contagion.

Amongst the poor, the want of good food and clothing, the indifferent light which does not allow them to see the dirt about them, and which they therefore do not remove, the overcrowding and bad ventilation, all render them exceedingly predisposed to the acute specific diseases. Accordingly we find that an outbreak of zymotic disease always makes head among the poor first; amongst them it gathers its strength and multiplies its points of contagion, before it attacks the rich man's family. Indeed, there is one disease, typhus fever, which is unknown except among the ex-

tremely destitute; clergymen and doctors occasionally die of it, their profession obliging them to visit the sick poor; but under no circumstances does it ever *spread* among people moderately well to do.

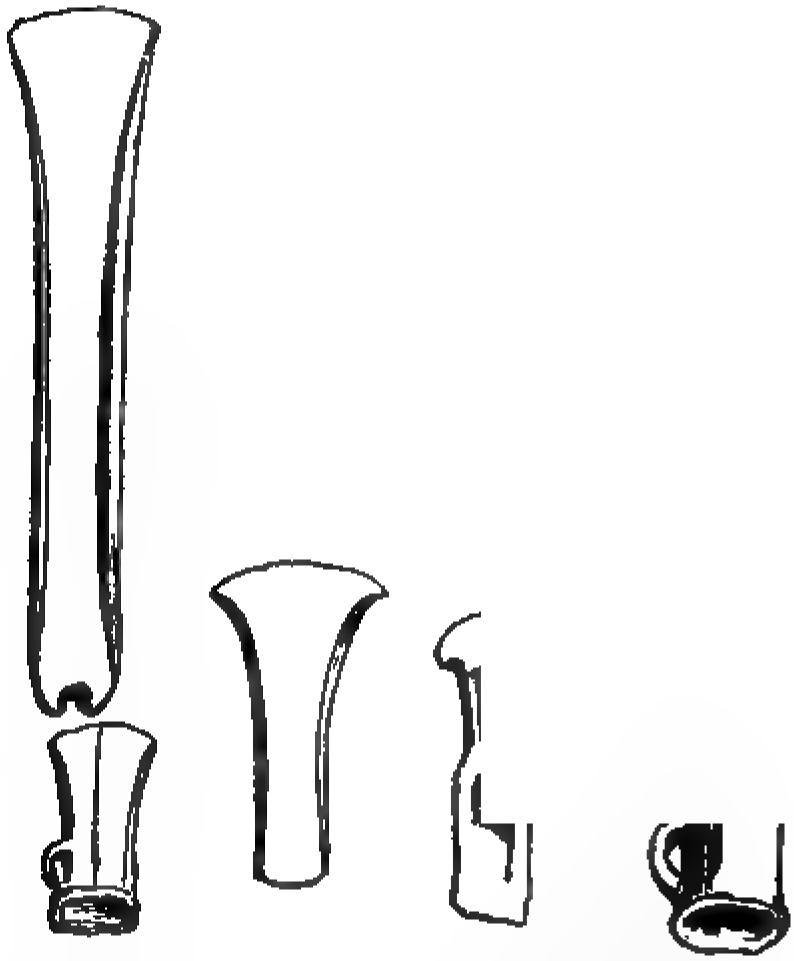
After a consideration of the preceding remarks, the question, "How may zymotic diseases be prevented?" may be more easily answered. Individual action can do little; it is to the State that we must look for efficient interference for the suppression of these complaints. With our English notions about the liberty of the subject, it will take years of active teaching and reiteration before any government will be sufficiently interested to make laws which will perhaps seriously interfere with the present prerogative of every English subject to spread infection. It has taken seventy years for the English Government to realize the value of Jenner's great discovery and to take steps to protect the community against periodical outbreaks of small-pox. It is to be hoped that another seventy years will not elapse before something is done to stop the spread of scarlatina, measles, or typhoid fever. Laws compelling the drainage and water supply to be at least effective, and forbidding the frightful overcrowding of dwellings which now prevails in every large town, ought to be made; every case of zymotic disease ought to be watched by officers of health, since that one case may become the centre of extension to the whole town, country, or even kingdom.

Individuals may, however, do a little in preventing these complaints, especially in their own households, but their exertions can scarcely reach beyond this. In the first place, let the water that is used for drinking be most carefully seen to *at all times*. No one should buy water of a company, the purity of whose source of supply is at all questioned, for water that looks, smells, and tastes perfectly good may convey the deadly poison of cholera or typhoid fever. The same consequences ought to follow the sale of unwholesome water to the public, as follow the sale of unwholesome meat or vegetables; or rather, the punishment should be greater, because the effects are more widely spread.

One of the most important means of prevention is also within the reach of individuals; it is quite simple, needing no apparatus or chemicals, and is the free and complete ventilation of all rooms and passages by means of windows opening on the external air, assisted, where there are opportunities, by fires in open grates. This method yields to none in efficiency; it is of far more use than any chemical means of disinfection, useful though these may

be; the only effectual plan is complete and thorough ventilation. When a member of a household has been seized with a zymotic disease, it is most important than no communication should be held with the sick room, other than is absolutely necessary; everything which comes from the sick bedside, or which has approached the sick man should be immediately destroyed with fire. When this is impossible from the nature of the article, as porcelain or glass, it should be placed in boiling water for several minutes, as soon as its contents have been got rid of. The disposal of water and other fluids which have been used by the sick is a matter of some difficulty. It is without doubt in the highest degree immoral to throw such refuse into a drain, whence it may easily pass on and infect others; the best plan seems to be to mix all these fluids with solution of chloride of zinc, or carbolic acid, and then to have them deeply buried in the earth with a quantity of disinfectants, far away from any wells or sources of water supply to any human habitation. If the refuse materials are more solid than liquid, they should be completely destroyed by fire.

A low degree of civilization sets a low value upon individual human life. If we compare the thousands of pounds lavishly spent by Government, where cattle only were concerned, with the small sums given grudgingly for the prevention and investigation—the first step in the prevention—of human disease, it will be seen how hollow our boasted advance really is. The lives of cattle must be protected because they are valuable property; the lives of men are apparently of little or no account. So long as the poor remain in their present wretched and unhealthy condition—a very poor population may yet be healthy—and so long as the death rate exhibits little or no decline in each succeeding year, so long are we on the moral level of barbarians in disregard for human life. This deep stain on modern civilization, the entire neglect of the sanitary condition of the poor, can only be wiped away by a great effort on the part of society in general, by the framing of laws, which shall be no half measures—the curse of English sanitary legislation—but which shall effectually and at once remove this evil from amongst us.



CELTS AND OTHER IMPLEMENTS OF BRONZE.

BY LLEWELLYNN JEWITT, F.S.A.

THE *Celt*, by which name the most general as well as the earliest implements of bronze, as well as their earlier prototypes in stone, are called, has been designated the "*ignus fatuus* of antiquaries," because, although constantly before their eyes, they are unable to grasp its nature, or to follow it with any degree of certainty through its many changes of form. I have no hope in this present paper, even if I had the temerity to try—which I confess I have not—of laying this ghost, or of catching the "will-of-the-wisp" while asleep and bottling him up for my reader's enlightenment! Neither have I the slightest intention of allowing him to lead me into the quagmires of theory in which he still wallows, or into any attempt to penetrate the cloud of vapour which surrounds him. Neither do I intend to broach any new theory of my own; but simply to throw together a few facts as to the forms of Celts, the objects along with which they are discovered, and the way in which it is possible some of them may have been used. At a future time I shall give a few words upon Celts of flint and of various kinds of stone, but at the present I shall confine myself entirely to those of bronze.

The most simple, and therefore considered to be the earliest, form of these implements is shown in the first of our engravings, and is

Fig. 1. Fig. 2.

evidently nothing more than a reproduction in metal, copper, or bronze, of the common type of the stone Celts, as will be seen on reference to the next engraving, on which a group of five of the more characteristic shapes of Celts of stone is shown. Figs. 5 and

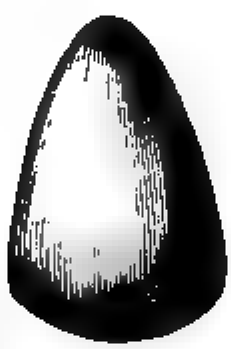


Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7.

7 will be seen to be of, as nearly as possible, precisely similar forms to those of bronze given above. This class of bronze Celts, which Sir Wm. Wilde judiciously denominates the "simple flat Celt" is a plain flat hatchet-shaped piece of metal, the two ends rounding gradually off to a sharp edge. The size varies considerably, from about three, to upwards of twelve inches. One of the largest on record is shown in the next engraving, which is twelve and a quarter inches in length, and eight and a quarter inches broad, and weighs no less than four pounds fourteen ounces. It is perfectly plain, and is three-eighths of an inch thick, gradually attenuated to

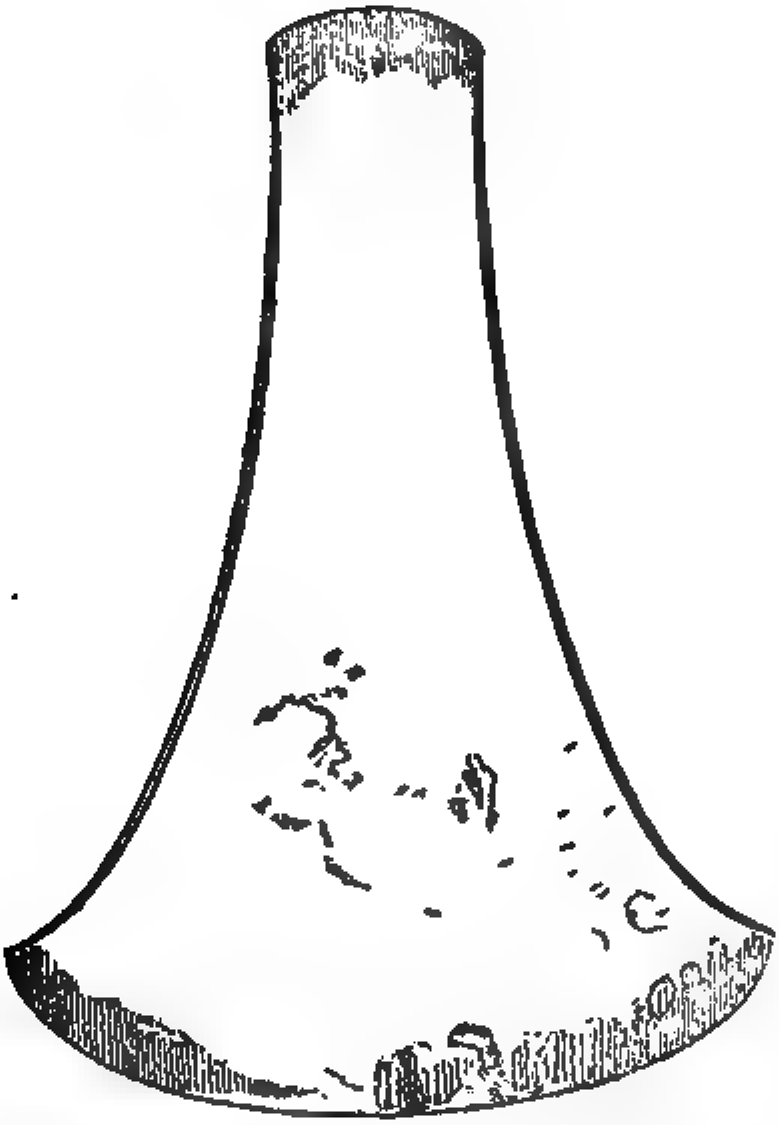


Fig. 8.

Fig. 9.

the ends, which are sharpened for cutting. Sometimes Celts of this form, as of others, are ornamented with herring-bone or other

Fig. 10.

Fig. 11.

Fig. 12.

lines, and exhibit in many other ways, a considerable degree of finish. Thus, on some of the next examples this kind of ornamentation, which is produced by slight cold-punching, or rude chasing, is shown. The examples so far engraved (to Fig. 12) are Irish, and are preserved in the Museum of the Royal Irish Academy, but they are, as I shall show, identical in form with English examples, and more especially with those from Derbyshire, and the adjoining counties. Two specimens will be sufficient to prove this—Fig. 13

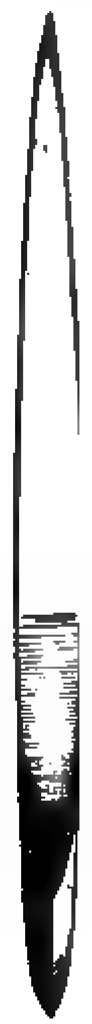


Fig. 13. Fig. 14.

being from Highlow, and Fig. 14 from Moot Low, both in Derbyshire. The resemblance between bronze implements of other kinds from Ireland, with those found in Derbyshire, is very striking, and will be noticed later on. The first advance on the plain flat form appears to have been the adoption of flanged edges. This will be seen on Figs. 14 and 15, where the edges are slightly rounded and flanged. The mode in which Celts of this primitive form were hafted seems to have been simply by passing the thin end transversly through a hole in a stick, or piece of wood, and binding the wood with a thong to prevent its splitting. It would thus become the type of our modern axe—the axe edge in front, and the tang behind.

The next general class of Celts consists of wedge-like implements more or less axe-shaped, in which the flange is sometimes made of considerable width; while in others the entire weapon is made thicker, with a groove (answering to flanged sides so far as it

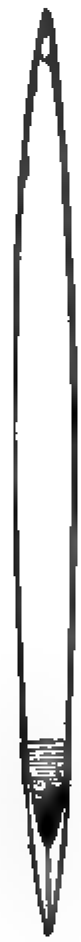


Fig. 15.

goes) on either side, and a stop ridge. Implements of this class are generally denominated "palstaves," from the old Scandinavian term *paalstab*, and it appears a convenient appellation. The form

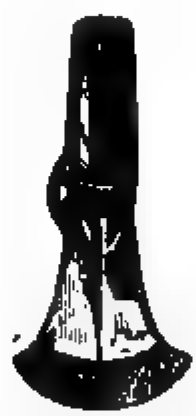


Fig. 16. Fig. 17. Fig. 18. Fig. 19. Fig. 20.

of the different varieties of palstaves will be best understood by the engravings. Fig. 18 being one of the slightly, and 19 one of the deeply, flanged variety, often termed "winged Celts," the latter having, like some of the other examples in this group, a central stop

ridge. Some of these deep flanges, or wings, are of leaf-shape, while others again are of lozenge form; both of which occur in Derbyshire, as well as in Irish and other examples. In some the edges of the flanges turn inwards, so as to grasp and hold the handle. In others a raised ridge occurs, doubtless for the purpose of holding the binding. Sir William Wilde, who has paid particular attention to the forms and peculiarities of these implements, describes the cutting edge as presenting "a great diversity from a very slightly curved line to that of the segment of a circle, the centre of which would be about the junction of the lower and middle thirds of the length of the instrument"—*i.e.* a third of the length of the implement from its cutting edge; but I have examined several, and indeed possess some, where the centre of the segment of the circle would be only a fourth, and in some instances only a little more than a *fifth* of the length of the implement, measuring from the cutting edge. They have been cast with the cutting edge tolerably sharp; but it is not unusual to find specimens which have been rubbed down on stone to produce a finer edge. It is not uncommon to find them worn, broken, or notched and hacked on the edge, as if they had been used for chopping hard substances, or, in course of warfare, or otherwise, been struck against the edges of others. The mode of attaching these palstaves to the handle appears to have been to split the end of the stick, or piece of wood, and then insert the narrow end of the implement in the cleft; binding it tightly round with a thong. The central stop-ridge served for the ends of the split handle to rest or "stop" against. In some cases this stop-ridge is very slight—indeed so slight, as, apparently, to have been of but little use, but in others it is developed into nearly half the thickness of the implement; while in others again it is surface-raised, and forms a semi-socket on each side the Celt. This raised stop, or semi-socket, was not unfrequently ornamented, as will be seen by the examples engraved.

Many palstaves are characterised (as are also socketted Celts) by a loop on the lower side, which was, doubtless, intended for securing it to its handle by a thong. This is well shown on Fig. 20, and also on Figs. 21 and 22, and was simply a loop, or eye, through which the fastening to the curved handle, whatever that fastening—whether of thong or of metal—may have been, was passed and re-passed. It is placed immediately beneath the stop and its orifice is chamfered or "countersunk" on either side, so as to prevent, as far as possible, the chafing of the ligature. Now and then, but very rarely, examples with a loop on *each* side have been found.

The next class, the *socketed Celts,* are of very different form from either of the others, upon which they are, evidently, a later improvement, and the result of a gradual development. I have shown that the flanges or wings of the palstave became gradually enlarged and, being occasionally curved inwards, formed a socket on either side for the reception of the the cleft ends of the handle. From this the idea of the formation of a single socket would be easy and natural to the Celt maker, and accordingly we find the palstave, as it were, cut in two; the thin end thrown aside, and the cutting half increased somewhat in thickness at its upper end, and made hollow for the reception of the end of the handle, or stick, which instead of being this time split, was inserted whole. The variety of socketed Celts is not so great as that of palstaves, but, nevertheless, many distinct varieties occur. In all, the loop, or eye, is close up to, or near, the hollow end. The general form will be

Fig. 21. Fig. 22.

clearly understood from the engravings, Figs. 21 and 22. The socket, and frequently the outer rim (as well as occasionally the general exterior forming the upper part), is sometimes circular, and at others oval, square, hexagonal, or octagonal, etc. The socket generally runs nearly the length of the Celt to the cutting-edge; and usually along its inside, the ridges, two, three, four, or more in number, where the core-pieces have joined, are perceptible. In the example, Fig. 21, which is a four-sided Celt, the hollow of the socket extends to about five-sixths of its length; but in the case of a ten-sided example in my own collection, Fig. 22, it extends to more than seven-eighths of its entire length—the general depth being, according to Sir William Wilde, about four-fifths. Implements of this kind are

usually of less size than those in either of the preceding classes. Among the forms of socketed Celts, one of very rare occurrence in England—and, indeed, even in Ireland only four specimens are known—is the plain square, and almost straight, wedge, engraved on Fig. 23 from an example in my own collection. It is four inches long, and is hollow to nearly four-fifths of its length. It has had a loop on its under side at the head, but this, along with a piece of the rim, has been broken off, showing that considerable force must have been resorted to in using it. Other varieties are straight on their sides, circular in section in the shaft, and the cutting-edge curved as in the other classes. Another kind is the gouge (Fig. 24), examples of which are found in both Ireland and England. In these the socket runs to more than three-fourths their length.

Fig. 23. Fig. 24.

Of the uses of all these implements it is unnecessary to say much. It is in this field that they have earned for themselves the name of *ignus fatuus*, and it is in this field—or rather in this bog—that so many antiquaries have attempted to build up their theories, which, like houses erected on a quicksand, have all, one after another, sunk and perished. We are told, by one writer, that they were used by besieging armies for displacing the stones in the walls of fortified cities, so as to gain an entrance; and we are also told that, stuck on the ends of sticks, gathered fresh from the trees when required, they were used as wedges and levers, and as crowbars. But surely common sense ought to show the absurdity of the idea that a stick of the thickness of the thumb, cut fresh from a tree, could ever serve the purpose of a crowbar; or that a Celt of a couple of inches or so in length, could ever be of much service to

a soldier in pulling down and making a breach in the walls of a fortified town. Wilson wisely says, speaking of the bronze axe, the palstave, and the socketed Celt, "they all appear to be more or less applicable to a variety of uses both as mechanical tools and warlike weapons, and any very nice attempts at discriminating between the various purposes for which they were designed, are more likely to engraft on the devices of primitive art, a sub-division peculiar to modern civilization than to throw a light on the era of their production. The Indian's tomahawk and knife are equally employed in war or the chase, as in the mechanical labours or culinary operations of the wigwam; and at a period greatly nearer to our own time than that of the bronze axe and Celt, the same implement sufficed the Scottish moss-trooper, or the Highland clansman for table-knife, *couteau de chasse*, and dagger."

We may therefore, I think, well dismiss wild and unnecessary theory—a theory which runs wild enough in one instance, to affirm that "barrows were not the tombs of agriculturists, gardeners, masons, or carpenters, but of chieftains and warriors" (what a pity the writer did not include bonnet-builders and cat's-meat sellers in his list!)—and content ourselves for the present with the simple belief that, with our pre-historic forefathers, the implements I have been describing were used for any purposes for which they could make them available, whether domestic or warlike.

Of their age it may be sufficient to say that they are usually found with undoubted remains of the ancient British period, and in ancient British localities. Occasionally, too, they are, as it is natural to expect, found with Roman remains in our own country. They may, there can be no doubt, as a rule, be ascribed to the Celtic period. The group of figures at the head of this article exhibits most of the types I have alluded to, and also gives representations of spear-heads, some looped in the manner of the palstaves and the socketed Celts, and others without loops. Of the more advanced of these as well as of bronze swords, I shall take another occasion to speak.

Of the mode in which Celts were manufactured we are, happily, not left to conjecture, for many moulds, principally of stone, in which they were cast, have from time to time been found. One of these will be sufficient for my present purpose. It is of stone, and contains moulds for casting four Celts, two of which are shown on the engraving. It is in the Belfast Museum. The subject of moulds is, however, too great a one for my present paper.

Before closing, it will be well to mention a class of bronze imple-

ments which can only have been intended for purposes of war, and which are of rare occurrence. They consist of a socket, or rather ferule, the upper part of which is armed with a number of deadly spikes, usually in three rows, alternately. The one I engrave

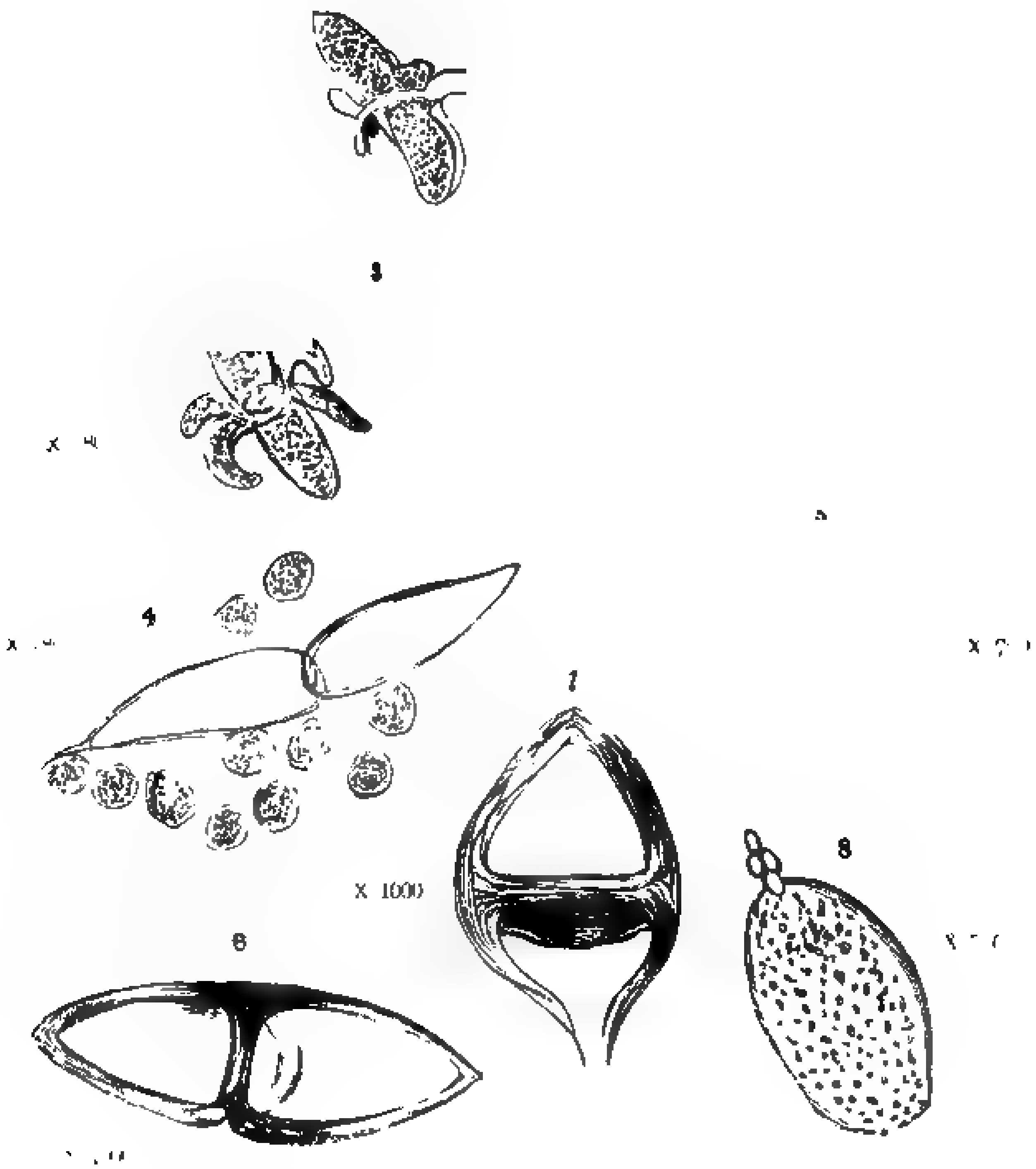
Fig. 25.

which is in the Museum of the Royal Irish Academy, will explain their general form. It was found in Ireland. In my own collection is a very similar one, found in Derbyshire; and others are preserved in other collections. It will be seen that this when firmly fixed at the head of a wooden shaft would, when wielded by a powerful arm, be one of the most terrible of weapons. My own example has been attached to its shaft by a rivet, and three of its spikes (of

Fig. 26.

which there were originally twelve) have, at the time when it was in use, been broken off on one side with great force.

I now close my present somewhat discursive paper, and shall hope at a future time to follow it up by a few words on other implements of bronze, as well as of stone and of iron.



THE PODISOMA FUNGI ON JUNIPERS.

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[illegible]

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THE JUNIPER FUNGUS (*PODISOMA*).

BY HENRY J. SLACK, F.G.S., SEC. R.M.S.

(*With a Coloured Plate.*)

In April, after some cold nights, I first noticed a great outcrop of the yellowish-brown fungus, *Podisoma*, on several "carpet junipers"* as the gardeners call them in my grounds. A more slender form of the same fungus attacked the so-called Irish juniper at the same time, but none appeared on numerous specimens of the *Juniperus Sinensis* growing near them, nor upon the *Retinospora ericoides* which formerly ranked with the junipers. The carpet junipers were so infested with this parasite as to look as if it was a fruit which they had produced in great abundance. Tufts of considerable magnitude grew out of the branches, bursting up through the bark, which was rendered soft and pappy. Similar, but somewhat smaller tufts sprang abundantly out of the smaller stems and among the leaves. The form of this podisoma is shown in the accompanying plate, and its texture and aspect resembled stiff jelly, or size. In many places the edges were of a darker brown, from the large quantity of coloured protosporescrowded together at certain points.

The tufts of podisoma dried up in a few days, but revived on placing portions of the plant on which they grew for a short time in water.

The "Micrographic Dictionary" gives a picture of a lobe, if I may so call it, of this fungus, in which the protospores are symetrically arranged in a sheaf-like form, each one growing at the end of a filament of the length required to form a regular pattern. Nothing of the kind could be seen in my specimens. They were full of protospores, which resembled two blunt sugar loaves stuck together at their bases and supported on filaments of all sorts of lengths. The greatest quantity of rich coloured protospores were aggregated in the darker rough-looking edges, but on cutting the superficial parts away with a pair of fine scissors, and then taking a slice out of the middle of a lobe, abundance of protospores were always found. Mycelium threads could be traced, though not very easily, in the softened tissues of the wood.

Turning to the books, I could not learn very much about these fungi.

In Berkeley's "Outlines of British Fungology," the podisomas

* Mr. Mitchell, of the celebrated Pilt Down Nurseries tells me the botanical name of these junipers is *J. squamata.*

which belong to the order *Puccinæi*, are described as having "peduncles extremely long, agglutinated by gelatine into a common stem, spreading out above into a clavariæform mass. Spores mostly uniseptate." Three species are mentioned: "*P. juniperi communis*, Fr., on stems of common juniper; *P. follicolum*, B., on leaves of common juniper; and *P. juniperi-sabinæ*, on stems of savin," of which Mr. Berkeley gives a plate, and this figure much resembles my No. 1.

One important peculiarity of the Puccinæi, besides their being parasitic on living plants, is their forming primary spores, "producing on germination secondary spores." The Puccinæi belong to the division of Coniomycetes, or dust-like fungi; they infest a great variety of plants, and one of them is the farmer's enemy, the *mildew* of wheat.

In Fries's systematic work I only found descriptions similar to those of Berkeley, and in Tulasne's splendid three volumes only brief mention of this genus. In Berkeley's "Introduction to Cryptogamic Botany" (p. 10), is a sketch of podisoma spores,* and a reference to the third volume of the "Annals of Natural History" (*sec* series), in which the production of spores from protospores is figured and described; but the details subjoined were not mentioned.

About a month after the first outcrop of the fungi on my shrubs they reappeared in great force, after some rain, and then I found nearly all the protospores had thrown out prolongations, as in Fig. 3, from the ends of which spores were produced. Many of the protospores were quite empty, as shown in Fig. 4, surrounded by spores. Many spores had produced mycelium threads.

Fig. 5 represents a protospore case burst at one end, and showing a sort of nipple in the middle of the septum dividing the upper from the lower portion.

Probably a considerable check would be given to the growth in subsequent years of these troublesome parasites if they were completely picked off the trees they infest on their first appearance, and before they had produced their true spores.

In Fig. 8 is shown a curious body which I only saw twice. They were extremely delicate little bladders filled with minute granules in molecular motion. I noticed them on crushing portions of the fungi under thin glass on a slide.

When the first crop appeared on the carpet junipers there were intermixed with the spores very pale tubes shaped like sausages, some-

* The *a* in this figure is like the protospores of podisoma; *b*, I do not understand.

times a little curved, at others straight, and filled with fine granules nearly colourless. I had to leave home at the time, and could not find out what they did or what became of them.

When these fungi were placed in plain water, detached from the plant, they softened and slowly decayed. A little sugar in the water preserved them longer, but did not make them comfortable. One so placed softened and filled the fluid with small floculent particles. After it had been in the fluid about three weeks a portion of the fungus which seemed gradually falling to pieces was placed under the microscope and found to contain innumerable minute cells, the majority round or roundish, which when magnified 240 diameters, looked from $\frac{1}{20}$th to $\frac{1}{8}$th of an inch in diameter. There were also multitudes of uniseptate cells much smaller and not the same shape as the protospores of the plant. They were nearly cylindrical with rounded ends, contained a few comparatively large granules, and were equally divided by a thin transparent septum. In size they were about 1-900″ in diameter. There were likewise abundance of mycelium threads, jointed tubes, etc.

I have not given these fungi specific names because I find the systematists seem to have considered slight differences of form and colour, coupled with the consideration of what juniper a particular specimen grew upon, sufficient to erect their species. I should have thought my two specimens were only varieties, as their internal structure, mode of growth, etc., is the same.

DESCRIPTION OF PLATE.

Fig. 1.—Podisoma on carpet juniper (*J. squamata*), slightly enlarged.

Fig. 2.—Podisoma on Irish juniper (*J. Hibernica*), slightly enlarged.

Fig. 3.—Protospores from P., on Irish juniper, sending forth tubular expansions to form the true spores + 240.

Figs. 4, 5, 6, 7.—Empty protospore cases, one burst at one end and one surrounded by spores + 720 and 1,000.

Fig. 8.—Thin vesicle with particles in molecular motion.

ON POISONS.

BY F. S. BARFF, M.A.

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No. III.

Of all the benefits to be derived from a more extended knowledge of chemistry, one can hardly conceive a greater than the influence which it must have on the affairs of common life. We constantly use materials, which may, from want of caution, cause serious evils, if not endanger life. Substances are used in the preparation of food, and even in its adulteration, which are extremely deleterious. A knowledge of the properties of these substances, and how they may be employed without danger, and under what circumstances they become dangerous, is of the utmost importance. If persons generally could by simple processes detect certain adulterations in articles of food, they would cease to be used, for the fear of detection would render their employment very hazardous to the adulterator. A person who uses copper cooking vessels, knows that cleanliness is absolutely necessary, but he does not know that other precautions besides this must be taken to prevent the food cooked in them from becoming impregnated with copper. Copper is not what chemists call an active metal. If copper be put in a solution of hydric chloride, from which the air has been expelled by boiling, so that no oxygen be present, and if the bottle in which it is placed be carefully corked so as to exclude air, the copper will remain unchanged for some time; slowly, however, it will become dissolved, that is, it will replace the hydrogen in the hydric chloride and form a green liquid called cupric chloride, the hydrogen gas being set free. Hydric chloride is formed of one part by weight of hydrogen, and thirty-five and a half parts of chlorine; sixty-three and a half parts by weight of copper replace the one part by weight of hydrogen, so that ninety-nine parts of cupric chloride are formed. If the experiment be performed in the same way; but if the vessel containing the copper and hydric chloride be left open, then the action will be much more rapid; the liquid will become green in a very short time, showing that the presence of air facilitates the combination of the copper and chlorine. In the acid liquid, in the presence of air, or free oxygen, the copper becomes oxidised, or converted into oxide, and the oxide is rapidly

acted upon by the hydric chloride—the hydrogen of which is not now set free, but unites with the oxygen of the cupric oxide. If a small quantity of the black oxide of copper be put into a vessel with hydric chloride, a green liquid is immediately obtained. These experiments are easily performed, and well illustrate the value of chemical knowledge, for they explain under what ordinary circumstances danger may arise from the use of copper cooking vessels. Cold water absorbs gases, in various proportions according to their solubility; this is seen in the case of a bottle of soda water. Under pressure the water holds in solution a large quantity of a gas, called carbonic acid, which escapes in part when the cork is removed; but after the soda water has got what is called flat, if it be warmed, bubbles of gas will be seen to rise to the surface, and a volume of carbonic acid, about equal to the volume of the water, may be obtained with care. Water dissolves about three per cent. of oxygen, at the ordinary temperature of the air, but when boiled all the oxygen is expelled. When, then, a liquid containing an acid substance, which will dissolve oxide of copper is boiled in a copper vessel, if no free oxygen be present, no oxide will be formed; but if the liquid be allowed to cool it absorbs oxygen from the air, and oxide is formed, which is dissolved by the acid liquid. In a case mentioned in the last article, a woman and her daughter were poisoned by eating sour krout; but the sour krout had been allowed to get cool and stand for two hours in the copper vessel, here the copper became oxidized during the two hours, and was dissolved by the acid of the cabbage. Whenever acid substances are boiled in copper vessels, at the junction of the surface of the liquid with the vessel, some oxide of copper must be formed and dissolved. German silver, of which spoons and forks are made, which is an alloy of copper, zinc, and nickel, containing nearly half its weight of copper, should be used with caution. A case is recorded of a lady who, after partaking of eels at dinner, was seized with headache, nausea, vomiting, and colic. The eels, of which she had eaten, had been cooked in an earthen vessel with butter and vinegar, a spoon had been used and left standing in the compound; the spoon was of German silver. On analysis it was found that some of the copper in the spoon had been dissolved, and had got mixed with the food; the spoon was well cleaned, and placed in a hot mixture of bread, butter, and vinegar, half an hour after the mixture had got cold, green spots were seen on it, and in twelve hours the spoon was quite green, as well as the butter in contact with it.* Not long

* Case recorded by Dr. Taylor.

ago, copper was largely employed to give a green colour to pickles. One would fear that the practice was not altogether discontinued, from the fact that some manufacturers find it necessary to state on their labels that their pickles are free from copper. From what has already been said, it is easy to conceive that copper may be present in pickles without being placed in them fraudulently, if copper vessels are used in their preparation. It is almost impossible to conceive how, under such circumstances, copper can be entirely absent, and the quantity must depend on the care taken by the workmen. It is most desirable that all pickles should be tested before being used; a method for doing this will be given when the analysis for copper is described. On the continent, some few years ago, it was discovered that a salt of copper was used in making bread, to assist the process of fermentation. When employed in small quantities it is said to make the bread much lighter, and of a very white colour. In larger quantities its presence could be detected, by the bluish colour it imparts to the bread.

In 1829 and 1830 the Belgian Government employed M. Barruel, M. Gauthier, M. Claubery, and M. Kuhlmann, to investigate a report that sulphate of copper was mixed with the bread in Bruges. They discovered that in 1816 and 1817, this salt of copper, under the name of alum-blue, was first employed by the bakers to raise their bread; and had since been employed very generally. Bread made in this manner was examined, and small pieces of crystallized sulphate of copper were found in it, when this was the case, the bread had a blue tinge. On chemical analysis copper was readily detected. Foreign syrups are also sometimes adulterated with copper. Sulphate of copper is used to decolourize the common sugar of which they are made. The copper is precipitated by lime from the syrup; but this is not always completely done, and some of the copper salt remains behind undecomposed. These syrups have sometimes been the cause of serious consequences to those who have partaken of them.

Sulphate of copper is used in medicine, sometimes as an emetic; for this purpose it is found useful where narcotic poisons have been taken. It was strongly recommended in cases of chronic diarrhœa by the late Dr. Elliotson, when combined with opium, on account of its astringent properties. The opium is used to prevent pains, which are caused when the sulphate of copper is used by itself; Dr. Elliotson found that given in half grain doses twice or three times a day, it had a very beneficial effect, and succeeded where

other astringent remedies had altogether failed. It has been employed with success in cases of epilepsy, where the disease has resulted from sudden shocks to the nervous system. In these cases its tonic effects have been very marked. Dr. Urban relates the case of a lady, who had never suffered from epilepsy, but who, on hearing of the sudden death of her husband, was attacked by this disease. She recovered after gradual treatment with sulphate of copper—the quantity she took was altogether twenty-six grains. Its action, as an astringent in diarrhœa, seems to be local, but its tonic effects in nervous disorders are evidently the result of absorption into the system. Sulphate of copper has been used with success in cases of croup. German physicians of great eminence have given their testimony in favour of its use in this disease, in doses of half a grain and under. It is stated that, in nearly fifty cases, only four were lost, when treated with this medicine, leeches being at the same time applied to the neck. Externally, both the sulphate and nitrate of copper, act as escharotics. In solution the sulphate has styptic properties, and is useful in stopping hæmorrhage. But care is necessary in its external application. Animals have been killed when it has been applied externally. Dr. Duncan killed a dog in twenty-hour hours by applying sulphate of copper to a wound.

The symptoms produced by poisonous doses of soluble copper salts are very similar to those produced by arsenic and corrosive sublimate, there are, however, differences which will be noticed presently. In copper, as in arsenical poisoning, there are local and remote symptoms. The local are produced by the irritating effects of this escharotic substance. Like arsenic, copper salts seem to adhere to the mucous surfaces and set up inflammatory action. When death takes place slowly, these appearances are more marked. That copper is taken up by the blood, has been proved by experiments on animals, and when acting through this medium on the system, the heart's action is interfered with—it loses its contractile power, and after death, red blood is found in its cavities. Difficulty of breathing, palsy of the lower extremities, tetanic spasms, and a general derangement of the nervous system are the results of its introduction into the circulation. When two grains of verdigris dissolved in water were injected into the jugular vein of a dog, they caused vomiting in seven minutes, then rattling in the throat, and in half an hour death. There were no particular morbid appearances found in the body after death. Half a grain killed a dog in four days; and in addition to the preceding symptoms, there was palsy of the hind legs for a day before death. Six grains of sul-

phate of copper, introduced into the stomach, killed a dog without producing any appearance of inflammation.* The symptoms which peculiarly characterise poisoning by copper salts, and which distinguish its effects from those of other irritant poisons, are the peculiar taste of the metal, which persists, even after the person is out of danger, and in jaundice, which is often induced by over doses of copper salts. A case is given by Dr. Christison illustrative of the slighter forms of poisoning with copper. Two women and two young men eat of an acid confection made in a copper vessel. The two women suffered from severe headache, constriction of the throat, nausea, colic, and extreme weakness. The young men, who had eaten more freely of the confection, had for some hours excruciating colic, severe pain in the mouth and throat, impeded breathing, and hurried irregular pulse; and for twenty-four hours they suffered severely from headache and prostration of strength. The matters ejected from the stomach are often of a green or bluish colour, and sometimes this tint is communicated to the skin, especially about the eyes. After death the skin is often yellow, and the internal parts exhibit the effects of an irritant poison in a marked degree. Sometimes the action has been so violent as to cause perforation of the intestines. Very frequently masses of green matter are found, owing to the presence of particles of copper salts. The best treatment that can be employed is, after using the stomach-pump, to administer soothing drinks. Albumen (white of egg), forms insoluble compounds with the salts of copper, and is therefore recommended as an antidote. It must, however, be given in large doses. Sugar was at one time supposed to be a good antidote, but there are great diversities of opinion on the subject. The idea originated with the fact that sugar precipitates copper from solutions of its salts, as the red suboxide.

The results of experiments performed on animals are by no means satisfactory, and it will be seen presently, that the conditions under which the red oxide of copper is formed, are not very likely to exist in the stomach of an animal. Metallic iron is, doubtless, a good antidote, the iron precipitates copper as metal from its solutions, and, as metal, it is harmless. The iron should be administered in the form of filings. Care should be taken not to administer acids, as they dissolve the compounds which copper salts form with organic substances. The analysis for copper is easy, unless it exist in the form of organic compounds. We shall leave the consideration of these complications to be treated of in another

* Cases recorded by Orfila, quoted by Dr. Christison.

article. Copper salts, as they are usually presented to us, are either blue or green in colour, and are usually prepared by dissolving the oxide in hydrogen salts. As has been already stated, the metal is but slightly soluble in hydric chloride, and dissolves but slowly in hydric sulphate. The red colour and peculiar disagreeable smell of copper is familiar to all. It is soft and ductile, and from the ease with which it can be worked, and from its chemical properties it and its compounds are largely used in arts and manufactures. Metallic copper is precipitated from solutions of its salts by iron. Cementation, in the metallurgy of copper, is the application of this process to the extraction of the metal from its ores. Very minute traces of copper can be detected in solutions by its reduction by iron. Suppose any substance, say for instance some ordinary pickles, are thought to contain copper, if a few bright needles be placed in some of the contents of the bottle containing them, if copper be present, it will be precipitated on the needles, and will coat them with a thin film of that metal. If the needles be carefully dried by blotting paper, and placed in an open vessel containing ammonia solution, the copper will be gradually oxidized and dissolved by the ammonia, and the liquid will acquire a blue tint, which will be deep or light in proportion to the quantity of copper present. This is an experiment which can be very easily performed, and will never fail to detect copper, if it be present in quantities sufficiently large to be injurious to health. Copper forms two compounds with oxygen, one, in which sixty-three and a half parts of it by weight unite with sixteen of oxygen. This substance is a black powder usually obtained by heating the nitrate until red fümes cease to be given off. It is also formed when copper is heated in air or oxygen.

The rust of copper is not oxide, but a green basic carbonate; it is this which gives the beautiful colour to ancient bronzes. Copper does not oxidize in moist air, nor is it able to take the oxygen from steam. A current of dry hydrogen passed over its oxide, when at a red heat, deprives it of its oxygen, water being formed, and pure metallic copper being left. If this finely divided copper be heated in air it burns readily, and in this way it is used as a means of taking oxygen from its mixture with nitrogen, in an analysis of atmospheric air. If black oxide of copper be melted with glass, it imparts to it a beautiful green colour, and is for this purpose largely employed in the manufacture of coloured glasses. When a solution of caustic potash is added to a solution of cupric sulphate, a bluish green precipitate is thrown down, which is the hydrated

oxide of copper; excess of potash does not dissolve it. On boiling the mixture, the blue precipitate becomes black, it ceases to be the *hydrated* oxide, and becomes the black oxide of copper. It is strange that, in the presence of water, cupric hydrate should become de-hydrated. The action of a solution of ammonia on copper salts, is at first similar to that of caustic potash, a blue hydrate is precipitated by it, but when added in excess, the precipitate is dissolved, and a clear transparent deep blue solution is formed. This action of ammonia is made use of in testing for copper. If a few drops of a very dilute solution of cupric sulphate be dropped on white paper and dried, they will hardly discolour it at all, but when a solution of ammonia is applied, they will directly become visible and of a blue colour. A colourless liquid will immediately acquire a blue tint on the addition of ammonia if it contain a cupric salt. This test taken alone might mislead the analyist—as nickel salts behave in a similar manner when treated by ammonia. It requires, however, much more of a nickel than of a copper salt, to produce a blue of the same depth, the nickel blue is also more violet in colour. The toxicologist would find no difficulty in distinguishing between the two, the precipitation of the metal copper on iron, the ferrocyanide reaction, which will be described immediately, together with its behaviour with potassic cyanide, sufficiently indicate the difference between copper and nickel, to prevent any mistake arising in an analysis, if due caution be used. The most delicate test for copper is the ferrocyanide of potassium, it gives a brown precipitate, or if the quantity of copper salt present be very minute indeed, a brown discolouration in acid solutions, the precipitate is said to be dissolved by ammonia. Copper chemically combined with arsenic, as cupric arsenite, is largely employed as a pigment; it is that beautifully bright green which is used in room papers. If a few drops of ammonia be placed on a piece of such paper, the green will be changed to blue by the ammonia, and the presence of copper being thus proved, that of arsenic may be fairly inferred. In analysing for copper; it is always usual to pass sulphuretted hydrogen gas through the liquid; when this is done a brown sulphide is deposited. After the sulphide is washed, it is dissolved in hydric nitrate; and here the blue colour of cupric salts shows itself at once, or is made apparent on the addition of ammonia. The compounds of copper which are usually met with, are the basic acetate or artificial verdigris. The copper in this salt may be found by the processes already

described, and the acetate may be discovered by its odour, or with greater certainty by heating the salt with alcohol and hydric sulphate, when acetic ether will be set free, which is known by its peculiar and agreeable smell.

The carbonate of copper, a basic-salt, which is formed by the action of moist air on metallic copper, and which is found native as malachite, when treated with hydric chloride is dissolved; the effervescence which occurs indicates the presence of carbonic acid, which may be confirmed by the white precipitate obtained, if the gas be passed into lime water. The sulphate of copper, called also blue vitriol and blue-stone, has been already described; the presence of the sulphate may be determined by the white precipitate which is thrown down from its solution by basic chloride, which precipitate is insoluble in hydric nitrate, and in hydric chloride. Nitrate of copper is a salt whose crystals have a deep blue colour; they are extremely deliquescent. The presence of the nitrate in this salt may be determined by the reaction already given at p. 182. Cupric chloride is green; it is very soluble in water. The method of detecting chlorides has been explained at p. 178. These are the most important salts of copper which have been, or might be, used as poisons, and in each one of them the method of testing for that metal is the same as that already described. There are, however, compounds of copper which, although they are not likely to be used as poisons, are of sufficient interest to deserve a brief notice here. When freshly precipitated cupric hydrate is treated with ammonia, it is dissolved, and a deep blue liquid is formed which has the property of dissolving woody fibre. If some clean cotton wool—which is the purest form of woody fibre—be shaken up with this ammoniacal solution of cupric hydrate, it is slowly dissolved, and can be again precipitated as a gelatinous mass by the addition, to neutralization, of hydric chloride. The salts only of the higher oxide of copper have hitherto been noticed: there is a lower oxide of copper which is composed of one hundred and twenty-seven parts by weight of copper to sixteen parts of oxygen. This oxide is of a reddish-brown colour, and its principal use is in glass-making. It produces the beautiful ruby-colour, so well-known in stained glass windows. The salts of this oxide are not blue, but white; cupreous chloride is a white solid, insoluble in water, but soluble in hydric chloride. By decomposing cupreous chloride with potash, the red oxide may be obtained; but the more ready way is to precipitate it from an alkaline solution, containing cupric oxide,

by means of grape sugar. The presence of organic matter in a solution of cupric sulphate, prevents the precipitation of cupric hydrate by potash; but if grape sugar be boiled with the mixture, the higher oxide is reduced to the lower, which is precipitated. Grape sugar exists naturally in many fruits; it is found crystallized in raisins, but it can be prepared by boiling common cane sugar with dilute hydric sulphate. It acts as a reducing agent, taking oxygen from bodies which do not hold it combined too strongly. Now these reactions are extremely interesting, as bearing upon a matter which has already been alluded to. It was said that sugar has been considered an antidote for copper, inasmuch as it causes its precipitation as the red oxide. The sugar which produces this effect is grape sugar, not cane sugar, which has no such action, and the circumstances under which grape sugar does it are not such as are likely to exist in the human stomach. Again, the fact that cupric oxide is not precipitated by potash in the presence of organic matter is also important, as it shows that unless organic matter be destroyed, copper cannot be discovered unless it be in excess of the organic matter present. Cupreous hydrate is like cupric hydrate, soluble in ammonia, but its solution is colourless, not blue; when, however, it is exposed to free oxygen, for ever so short a time, the lower oxide becomes oxidized into the higher, and a blue colour appears; this solution, therefore, is a most excellent test for free oxygen. When cupric salts are heated, so as to drive off their water of crystallization, they become white, and in this condition they rapidly take up moisture, and become blue again. This property is often made use of in the laboratory for taking water from alcohol. Any part of the water can be abstracted from spirits of wine by distillation; about ten per cent. remains behind, and this is frequently got rid of by distillation from dry cupric sulphate. If it be desired to detect the presence of moisture in any substance, supposed to be dry, this white cupric sulphate will do it with unerring certainty, for the slightest trace of moisture will cause it to assume a blue colour. A difficulty has arisen in medico-legal investigation from the fact that copper has been proved to exist in the blood and tissues of the body, as well as in many kinds of food which are taken for its nourishment. The brown paper, in which articles are wrapped up, has been proved by Gahn to contain copper. Rose detected copper in sugar, Meisner and Bucholz discovered that it was naturally present in several kinds of vegetables. The wheat, from which our bread is made, before it

has received any further adulteration, has been proved by an eminent Dutch chemist (M. Lefebvre), to contain copper. The researches, however, of M. Boutigny, have gone far to allay any apprehension which might exist as to danger to health arising from the occurrence of this poisonous mineral in articles of food, for he found that substances, such as wheat, vegetables, etc., only contain it when they are grown in a soil into which it has been introduced as manure, and that the manure from large towns almost invariably contains copper, but that it exists in it in such minute quantities that it cannot possibly produce any serious effects on the health of those who consume the food which grows in soils fertilized by it.

The presence of copper in the tissues of the body, where none has been taken, does not seriously affect the analysis for copper when administered in poisonous doses, because it has been found by M. Devergie that weak acetic acid will not dissolve that copper which exists in the body naturally, and M. Orfila asserts that such copper is only to be obtained from the matters with which it is combined by absolute incineration.

OTHER WORLDS.*

As soon as the human mind is penetrated by the fact that the stars and planets which spangle the heavens are something more than night's candles, speculation makes them the abode of some kind of intelligence or power. In very early days of human history, astrology assigned the planets, or "wanderers," to various deities as habitations. Sirius received divine honours from the Egyptians, from the association of a particular rising of the star with the great annual event of that country, the overflow of the Nile; and we are all familiar with the question in Job, "Canst thou bind the sweet influence of the Pleiades, or loose the bands of Orion?" But whatever ideas the ancients had of the importance of celestial bodies, it was reserved for Newton and his successors to form accurate notions of the size and weight of the Sun and his attendants, and we are just now beginning to compute, upon probable data, the masses of some of the fixed stars.

The conception of the planets as globes more or less resembling our own Earth was naturally followed by the supposition that they were inhabited by creatures analogous in organization to the earth-born forms around us, and the history of speculation and controversy in connection with this subject affords curious illustrations of cautious reasoning and wild fancy, devout contemplation, and superstitious absurdity. Mr. Proctor, taking advantage of the most recent discoveries, has carried the subject much further than Whewell and Brewster, and has displayed in this, and in other branches of his subject a very remarkable capacity for original thought. He has succeeded in uniting qualities rarely found in the same work, which are only reconciled by really great thinkers—the charm of popularity and the profoundity of research. Any one of ordinary education may read "Other Worlds" with delight, and find little he cannot easily understand, while to the scientific student it will commend itself as the most remarkable book of the day, for the boldness of its speculation and the harmony of its results. We do not say that Mr. Proctor is right in all the new views and theories he brings before us, but he stands alone amongst the rising generation of astronomers for the extent to which he pushes inductive reasoning, and the broad flood of light which he

* "Other Worlds than Ours: the Plurality of Worlds studied under the Light of Recent Scientific Researches." By Richard A. Proctor, F.R.A.S., author of "Saturn and his System," "Sun Views of the Earth," "Half Hours with the Telescope," etc. (Longmans.)

sheds over extensive groups of facts left by other philosophers in unprofitable disconnection. He possesses that combination of the analytical and synthetical faculties which has given such a lustre to the name of Herschel, and which is so splendidly exhibited in the labours of Lyall and Darwin. It was because we recognized this quality in Mr. Proctor that we gave him so much space in the INTELLECTUAL OBSERVER and in the STUDENT when he was comparatively unknown; and, although prophecies are safest when they follow the event, we do not hesitate to express our belief that his labours will have a most important influence in the progress of astronomy, and will eventuate in considerable modifications of scientific thought.

There are two classes of speculation which man may legitimately indulge in concerning the habitability of other worlds—the one strictly scientific, the other more or less fanciful and poetic. When positive science leaves us, we may imagine that "millions of spiritual creatures walk the earth unseen," and we may locate them in regions where no organized beings that the anatomist could dissect, or the microscopist examine, could possibly exist. There may also be animals capable of existence under conditions of heat or cold, excess of light, or prolongation of darkness, which would be fatal to any terrestrial creature we are acquainted with, or by fair analogy can suppose to belong to the sort of fauna we know; but it is obvious that we soon get quite out of our depth if we depart very far from that which has been actually ascertained, and speculation is only fanciful guessing when it is not subordinated to fact.

Mr. Proctor summarily—perhaps too summarily—dismisses both Sun and Moon as not "intended to be habitable," but he makes great use of our central luminary in his admirable sketch of solar physics, and connects him by a series of ingenious speculations with the entire *Cosmos* to an extent which no previous writer has attempted. Perhaps the most important part of this section is the revival of the recent, but almost abandoned, notion, that the supply of solar light and heat is kept up by the precipitation of streams of meteors upon the Sun's surface. Mr. Proctor considers the solar corona as meteoric. We must refer to the work itself for a full exposition of his reasons for these opinions, but we will cite one passage, in which he says, "We know that the auroral light is associated with the Earth's magnetism, and that meteoric bodies are continually falling upon the Earth's atmosphere. We know, also, that the Sun exerts magnetic influence a thousandfold more intense

than that of the Earth, and that in his neighbourhood there must be many million times more meteoric systems. But we have other and independent reasons, which must not be overlooked, for considering the corona to be of some such nature as I have suggested. Leverrier has shown that there probably exists in the neighbourhood of the Sun a family of bodies whose united mass suffices appreciably to affect the motions of the planet Mercury. Mr. Baxendell has also shown that certain periodic variations in the Earth's magnetism point to the existence of such a family of bodies, and he has been able to assign to them a position according well with that determined by Leverrier. Now, whatever opinion we form as to the exact character of the system of bodies pointed to by the researches of Leverrier and Baxendell—whether we suppose that system to form a zone around the Sun, or that (as I believe) the system is merely due to the aggregation of meteoric perihelia in the Sun's neighbourhood—we may be quite sure of this, that during a total solar eclipse the system could not fail to become visible. Hence there is a double objection to the view put forward by Mr. Lockyer and others." Mr. Proctor adds, that "if the corona and zodiacal light are really due to the existence of flights of meteoric systems circling around the Sun, or to the existence in his neighbourhood of the perihelia of many meteoric systems, then there must be a supply of light and heat from this source very nearly, if not quite sufficient to account for the whole solar emission."

Wherever the Sun receives his energy from, he is the source of the most important physical and vital movements of the planets which revolve around him as he journeys through space, and one of the chief points of attention, when we are speculating on the habitability of any planet, is the quantity of solar influence it receives.

Mercury, for example, must be a difficult globe for creatures such as we know to dwell in; and if it is inhabited, as is probable, we cannot help thinking the Mercurials must be a peculiar race. A year of about three months would not of itself be very important, were it not that it comprises seasons of great difference of temperature. "When he is nearest the Sun, he receives ten and a half times more light and heat from that luminary than we do; but when he removes to his greatest distance, the light and heat he receives are reduced by more than one-half. Even then, however, the Sun blazes in the skies of Mercury with a disk four and a half times larger than that which he presents to the observer on Earth."

To what extent the inclination of Mercury's axis to his orbit

adds to the seasonal changes that must result from his approach to and recession from the Sun, is not known; but if any living objects dwell on his surface that cannot stand violent roasting, they must be protected by his atmosphere and clouds. The Mercurial air may be vapour-laden, and cloudy, and telescopically it looks dense, but there is a difficulty, which Mr. Proctor does not clear up, in understanding how clouds of water-vapour can be formed or sustained in the presence of such a blazing solar heat; though in the absence of precise information concerning the planet's inclination to his orbit, we scarcely know how to speculate. Our clouds result from warm moisture-laden currents being acted upon by cold currents, and we may ask whether during the Mercurial perihelion any portion of him is likely to have an opportunity of growing cold. If the Sun flamed upon his surface through a clear sky, it would raise it to a dull red heat, and we may doubt whether nocturnal radiation would cool any portion to boiling-water temperature in the twelve hours or thereabouts of his ordinary night. If one pole has a long arctic day while the other lies in a corresponding night, creatures less fond of fire than the Salamanders of the Rosicrucians would have to migrate to the nocturnal region as the daylight came on, and then their path would be something like Lucifer's walk over the pavements of Pandemonium, as pictured in "Paradise Lost." Mr. Proctor suggests they may have tunnels to protect them, and engineering would be easy, from the comparative weight of bodies on his surface being so much less than on our Earth—probably about seven ounces to a pound—a condition of things which, as Mr. Proctor points out, might enable mammoths to rival greyhounds in agility.

Venus would probably be too hot in her equatorial regions for any creature we know of, but her temperate and polar regions would come nearer to our ideas, with the help of her cloudy sky. There seems, however, a doubt as to the inclination of the axis of Venus to her orbit, and her seasons may be subject to tremendous extremes. If her inclination, however, is somewhat like that of the Earth, her climate may not differ excessively from our own. Secchi has obtained some imperfect spectroscopic indications that the atmosphere of Venus is similar in chemical constitution to our own, and all observers know how constantly and almost completely her body is veiled in clouds, that give a dazzling reflex of solar light.

It is when we come to Mars that we recognize features strongly resembling those of the globe on which we live. The inclination of

Mars' axis is about $27\frac{1}{2}°$—our Earth's being $23\frac{1}{2}°$; his year is about as long as 687 of our days, and his day nearly 40 minutes longer than ours. His orbit is considerably excentric, and the summer of his northern hemisphere occurs when he is nearest the Sun. Altogether, he must be subject to greater extremes than we are in the changes of the seasons. Mars is a remarkably interesting, though somewhat difficult telescopic object. We easily notice on favourable nights—that is to say when the Terrestrials and the Martials have both clear skies in the regions of the observer and the observed—appearances of continents and seas, and at appropriate times of snowy poles, and the spectroscope confirms our interpretation.

Mars may be admirably studied in the stereographic photographs made and published by Mr. Browning. These, as we have before explained, are founded on charts compiled by Mr. Proctor from the best drawings of the planet. From the charts Mr. Browning constructed a Martial globe, and from the globe the photographs were taken.

A somewhat startling condition follows the law of gravitation, and makes the smallest planets the most convenient abodes for the largest animals. Mars has an average density of nearly four times that of water, or less than three-quarters of that of our Earth, and his globe is only 5000 miles in diameter; hence "a Daniel Lambert on Mars would be able to leap easily to a height of five or six feet, and he could run faster than the best of our terrestrial athletes. A man of his weight, but proportioned more suitably for athletic exercises, could leap over a twelve-feet wall. On the other hand, a light and active stripling removed to Jupiter would be scarcely able to move from place to place. On the Sun his own weight would nearly crush him to death"! When one of Mars' hemispheres is in its winter season, cloudy skies cover its features, and from the abundant precipitation of moisture, the ruddy planet may have its "children of the mist" amongst its highlands and its fertile pastoral plains, though we may doubt the tint of the planet arising, as some astronomers supposed, from the vegetation being red.

Very different are the conditions offered to our contemplation by "Jupiter, the giant of the solar system." With a diameter of 85,000 miles, or nearly eleven times as long as that of our earth, a surface 115 larger, and 1,200 times the terrestrial volume, gravity at his surface is only $2\frac{1}{2}$ times as great, owing to his materials being on the average less dense. Still, as every animal would

weigh $2\frac{1}{2}$ times as much as on the Earth, we may easily perceive that few creatures we are acquainted with could bear the burden of themselves. Mr. Proctor alludes to old Wolfius as cited by Admiral Smyth, and who fancied the Jovial men were at least as big as Og, king of Bashan, because he traced a certain proportion between the diameter of the pupil of the human eye and the height of the body. Jupiter being much further from the Sun than the Earth he said the pupils must be wider, and the men increased in the same ratio! Taking gravity as a guide, Mr. Proctor remarks, we might make the Jovials to be pigmies, so that Tom Thumb would be a giant amongst them. Whewell considered the Jovians "pulpy and gelatinous, living in a dismal world of water and ice with a cindery nucleus," but no appearances, or known facts of the great planet, necessitate such an idea. Although this planet receives only about one twenty-fifth of the light and heat we get from the Sun, there might be considerable compensation from the action of his atmosphere in obstructing more than ours does the loss of heat by radiation into space.

The Jovial year would make nearly twelve of ours, and his equator being "inclined little more than three degrees to his orbit," he would not suffer as we do extreme cold at the poles. Mr. Proctor regards it as probable, that if there is a flora and fauna on this huge globe, it is probably constructed on a smaller scale than ours; and he cites, with some expression of doubt, an opinion of Whewell's in his "Bridgwater Treatise," that the specific gravity of bodies on Jupiter would be fatal to such plants as ours, as upon the Earth the motion of sap is partly regulated by gravity, and any material disturbance in the amount of that force would not suit our vegetation. Probably, if such a change took place gradually it would only involve corresponding changes in vegetation not greater than those which have occurred over and over again upon our planet in geological times; but, if on Jupiter increased gravitation made it more difficult for fluids to ascend, diminished solar influence would also lessen the rapidity of chemical changes, and we might have slower growth. The power of capillary attraction we cannot estimate, as we know nothing of Jovial structures, but it might be as well proportioned to the other forces as with us.

If Jupiter's polar and equatorial climates at various seasons differ less from each other than ours, this fact, together with the much smaller quantity of solar action upon his surface and atmosphere will allow him a great immunity from the wind-storms so common with us, and, so far as plants were concerned, one important de-

mand for strength would be removed, and trees which our cyclones and tornadoes would tear to pieces, might luxuriate in peace upon a quieter planet.

We are very glad to find that Mr. Proctor has taken several occasions for rebuking the folly of that species of natural theology which too readily presumes to know exactly why the Creator has acted in a particular way: thus, to say nothing of the "Bridgwater Treatises," so scientific a writer as Admiral Smyth spoke of the perennial summer of Jupiter as "a striking display of beneficent arrangement." Mr. Proctor adds, "that the arrangement *is* beneficent we need not of course question. But that we can recognise the way in which it is beneficent is quite another matter. If Jupiter's great distance from the Sun is compensated for by this peculiar disposition of his axis, and we are to admire the beneficence thus displayed, are we, therefore, to find fault with the Creator for not dealing similarly with Saturn, Uranus, and Neptune, which, being further from the Sun, have greater need than Jupiter of some special adaptation of the sort?" The splendour shed by Jupiter's four moons have often formed the basis of similar comments, but Mr. Proctor shows that, "if they could be all full together they could only send to the Jovials about one-sixteenth part of the light we receive from the full Moon. But, as a matter of fact, they cannot all be full together." All may be visible together, but only one full.

The mean density of Jupiter is about one-third greater than water, or "rather less than one-fourth of the Earth," and Mr. Proctor adds, "it is worthy of remark that his density is almost exactly the same as the Sun's, and considerably greater than that of the three other outer planets hitherto discovered." But then comes the question of what is the real size of the planet?—where does his atmosphere end and his body begin? It has usually been supposed that the light belts, so conspicuous in most years when the planet is surveyed through a good telescope, are clouds, and that the dark stripes are the body of the planet; but this latter portion of the theory is open to great doubt. Mr. Proctor says, "if the bright belts really are cloud-belts, and the dark belts the surface of the planet, then on the edge of the planet's disk we ought to see some irregularity of level—the cloud-belts projecting slightly beyond the real outline of the planet, if the atmosphere have that enormous extent which some astronomers have supposed. Whether such an appearance has ever been looked for, I do not know, but it has certainly never been detected." From this reasoning he concludes

that either the dark belts belong to a lower cloud-layer, or that the atmosphere is not extensive enough to interfere with our measurements of the planet's disk.

The remarkable changes of colour and form noticed in 1869-70, by Mr. Browning and Mr. Slack, and subsequently seen by other persons, seem to indicate enormous changes going on in Jupiter or his atmosphere, quite distinct from terrestrial storms and clouds. The exquisite drawing by Mr. Browning, which we recently published, and the paper by that excellent observer, will enable our readers to form their own opinions upon this point. The great outburst of yellow light can scarcely be imagined to arise from an absorption of the red and blue portion of the solar rays. It seems connected with internal actions, perhaps of an extensive igneous kind. Mr. Proctor thinks, from a variety of appearances and facts, that the planet is, to some extent, self-luminous, and he associates together the small density of the planet, his extensive atmosphere, and the colours, shape, and changes of his belts. Considering his distance from the Sun, he regards it as impossible that solar heat could vaporise enough water to load his atmosphere with enormous clouds, or cause such tremendous disturbances as are seen to take place in it. Taking analogy for a guide, he pictures Jupiter as still "a glowing mass, fluid probably throughout, still bubbling and seething with the intensity of primæval fires, sending up continually enormous masses of cloud to be gathered into bands under the influence of the swift rotation of the giant planet." Jupiter, thus examined, belongs to the category of Suns, and affords a certain allowance of light and heat to his attendant planets, the four satellites, which may resemble habitable planets rather than our Moon. It appears that there is some reason for supposing that Jupiter emits a certain portion of self-made light. Zöllner found that he sent to us much more light than a planet of equal size would do at the same distance from the Sun, and constituted like Mars, the Moon, or the Earth; and Bond calculated that he sent more light than he received. Mr. Proctor says that, "if Jupiter do not shine in part by native light, his surface must possess reflective powers nearly equal to that of white paper," which is scarcely credible. We recommend our readers to consider carefully all Mr. Proctor's reasoning on this subject, we have only indicated its character; and pass to another celestial object, Saturn, with his wonderful appendage of rings and satellites. Saturn is about 700 times as large as the Earth, and has the remarkably low density of only three-quarters that of water, so that he could float in a sufficiently big

sea. He is the lightest of known planets, and being nearly ten times as far from the Sun as the Earth is, he receives about one-ninety-first part of the solar light and heat that reaches us. Matters are so arranged in this grand planet, that in latitudes corresponding to that of London or Paris, the Sun is totally eclipsed for more than five years in succession, while in the latitude corresponding to that of Madrid, he is totally eclipsed for nearly seven years in succession. This effect of the ring system, added to the distance of the planet from the Sun, make us suppose that, if inhabited at all, it must be by creatures quite different from those on the Earth. But what is the condition of Saturn? Is he a solid globe at all, or is the major part still fluid from internal heat? The changes of his belts, and the remarkable colours first noticed by Mr. Browning, whose drawing we published in a former number, and the very small density, seem to indicate that he is an unconsolidated, perhaps unfinished world. Mr. Proctor considers that the distortion of the disk of this planet, noticed by Schröter in 1803, by Sir W. Herschel in 1805, and by Kitchener in 1818, was not an optical delusion, but a real fact, arising from vast changes in the planet itself; and it is curious that Airy and Coolidge (Cambridge, U.S.) observed disturbances at other times, and likewise the two Bonds.

Mr. Proctor says, "Why Saturn rather than Jupiter should exhibit these mysterious changes of figure, is readily explicable when we remember the near coincidence of the planes in which the Jovial satellites move with the orbital plane of their primary. There thus always results a close agreement between the zone on which the satellites exert their greatest disturbing influence and that most influenced by solar action. No such coincidence exists in the case of Saturn, whose satellites travel in a plane inclined nearly 30° to that in which their primary travels." Saturn, as well as Jupiter, may be a sun—a secondary one in our solar system—just as our Sun may be related to some grander primary, as has long been supposed.

The remoter planets, Uranus and Neptune, are respectively 74 and 105 times as large as the Earth, and their mean density is about that of water. The Sun will look to Uranians about $\frac{1}{390}$th of the size he does to us, and to the Neptunians about $\frac{1}{900}$th of ours. Added to this, Uranus has his equator inclined to his orbit about 76°, and as his year would swallow up 84 of ours, his winters must, so far as solar influence is concerned, be tremendously severe. "For twenty years, in a latitude corresponding to that of London, the Uranians—if there be any—never see the small Uranian Sun;"

and in all latitudes nearer the pole the Uranians have winters lasting from twenty years to upwards of forty." Here there may be indeed "thrilling regions of thick-ribbed ice," unless, as it is probable, Uranus may still be heated by internal fires. Mr. Proctor thus sums up his conclusions respecting the outer planets. "We seem led to the conclusion that the planets which lie outside the zone of the asteroids are distinguished from those within that belt, not merely, as had so long been recognized, in the attributes of size, density, rapidity of rotation, and complexity of the systems existing round them, but in this more important and interesting circumstance, that they and their dependents are real miniatures of the solar system. Four suns they would seem to be—not, indeed, suns resplendent like the primary sun round which they travel—not heated to incandescence as he is, but still supplying an amount of heat proportionably far greater than the light they give forth."

If their materials are similar to those of our Earth, we imagine the heat that would render them fluid enough for the vast and rapid changes we have alluded to must also make them incandescent, and that we must look to the nature of the atmosphere for an explanation of their not emitting more light. Speculations of this sort may usefully guide us to investigations, whether they are true or not. Without any theory, investigation seldom leads to important discovery. Mr. Proctor is very likely to prove right, but if not, his hypotheses are legitimately formed, and tend to further the elucidation of the truth, whatever it may be.

When Mr. Proctor comes to speak of the Moon, we think he is too hasty in assuming that it has no atmosphere. We should like to know his opinion a few years hence, if he spends some of his evenings in watching with a good telescope changes of colour, etc., that occur on our satellite's face. With a long day—of a fortnight—during which the Sun pours a flood of heat and light upon her surface, heating it above the boiling point, and with a corresponding night of rapid cooling and severe frost—if there is anything to freeze—we should not select the Moon as a habitation; and the Selenians, if there be any, must be a peculiar race, though whether, as Washington Irving stated, they are pea-green, and have one eye in the middle, may be open to doubt. We have little faith in the opinion that the Moon is in a later stage than our Earth, that once she was habitable, but that now her water and air have disappeared, and she is a barren waste, alternately scorched and frozen in her day and night. The telescopic aspect of the Moon points clearly to enormous igneous and volcanic action, but it does not

point with equal clearness, if it points at all, to a succession of changes operated by aqueous and atmospheric causes. If she has passed through such stages, evidence thereof should be discernible, and the attention of telescopists may well be directed to their forms. We hope Mr. Proctor will have something more to say about this by-and-bye.

In the chapter on meteors and comets Mr. Proctor shows why he supports the notion that meteors falling into the Sun sustain his heat. He points out that since Professor Thompson abandoned this theory, additional evidence has been discovered to strengthen it. The supply of meteors in space must be enormous, for, at a very low estimate, the cluster which we traverse in November must contain one hundred thousand millions; and, supposing them to be very small bodies—one-hundredth of an ounce each—we should have about 28,000 tons in this system alone; and many of the millions of systems that probably exist, may have within them bodies of considerable mass like the great meteoric stones that are occasionally found to fall upon our earth. Mr. Proctor considers, that in the neighbourhood of the Sun there must be numbers of intersecting meteoric systems, and that collisions must be frequent between bodies travelling at the rate of 200 miles a second. The sudden arrestation of such velocities, and the fall of the colliding bodies on the Sun, must necessarily give rise to a great development of heat. It is interesting to find the meteoric theory of solar sustentation thus rehabilitated with considerable probability. If, true, our Sun swallows immense quantities of meteoric food, and must at length be noticeably increased in bulk unless some unknown cause operates for the dispersion of his material, and his supplies are simply reparations of waste matter as well as restorations of spent energy.

The Earth, Sun, and planets, must be "growing" if they receive a continual rain of meteoric matter; and Mr. Proctor is disposed to consider "that countless millions of meteoric systems, travelling in orbits of any degree of excentricity and inclination, travelling also in all conceivable directions round the centre of gravity of the whole world, go to the making up of each individual planet." This theory, of course, supposes that at former periods meteoric systems were more numerous than at present. "A marked tendency," he says, "to aggregate round some definite plane, and to move in directions which referred to that plane corresponded to the present direction of planetary motion, would suffice to account for the present state of things. The effect of multiplied collisions would be to eliminate orbits of exaggerated excentricity, and to form systems travel-

ling nearly on the mean plane of the aggregate motions, and with a direct motion. Further, where collisions were most numerous, there would be found not only the most circular resulting orbits, not only the greatest approach to exact coincidence of such orbits with the mean plane of the whole system, but the bodies formed out of the resulting systems, would then exhibit rotations coinciding most nearly with the mean plane of the entire system."

It may be objected to this theory, that it is not complete. It seems to require the previous formation of a great Sun to bring the other bodies into position, and it offers no explanation of how the meteoric bodies were themselves formed, and by what means their motions were produced. We cannot, however, expect a complete theory in the present state of knowledge, nor can we suppose, if we have regard to the limitations of our inquiries in other directions, that we have any prospect of arriving at a beginning. All that we are likely to do, is to trace a long series of changes operated by definite laws. Mr. Proctor's theory is decidedly Darwinian. His meteors revolve in a variety of orbits; they have their battle of life, the stronger swallowing up and feeding upon the weaker, and, finally, those only survive that have the fittest orbits, and were best able to carry on the great work of progression from elementary to higher forms of solar or planetary being. The nebular theory, as ordinarily accepted, does not account for many peculiarities of the solar system, and in some particulars is difficult to reconcile with them. By calling in the aid of meteor streams, Mr. Proctor certainly makes an advance in probable explanation. He says, "assuming that the region of maximum aggregation was that where the influence of the ruling centres first became so far diminished with distance as to render the formation of a great subordinate aggregation possible, we should have the innermost of the outer series of planets also the most bulky: and next within that giant planet we should find a relatively barren space, cleared of material not only by the Sun's still powerful influence, but also by the influence of their first important subordinate aggregation."

Jupiter's size is thus accounted for, and the smallness of Mars. We likewise see a physical reason for the great space between Jupiter and Saturn. Mr. Proctor further shows that the variations in the inclination of the axis of the various planets to their orbits, and other particulars, are more easily explicable on his theory than on the nebular hypothesis of Laplace.

We pass over an interesting chapter on "Other Suns than Ours," embodying the results of recent discovery, and abounding

in original thought, and we come to subjects that have been partly illustrated by Mr. Proctor's papers in our own pages. He has recognized a remarkable community of motion amongst the stars, which opens up grand views of the extent and unity of the stellar system. Our readers will do well to refer to the papers we have published at various times, and especially to the chart showing the distribution of nebulæ. These curious bodies—we mean those which are really such, and not mere star clusters—*seem to withdraw themselves from the neighbourhood of the galaxy.* In the northern heavens they cluster very definitely towards the pole of the galaxy; in the southern they are arranged in streams and clustering aggregations but the galaxy itself is, in either case, left almost clear of nebulæ. Mr. Proctor also points out the remarkable apparent connections of nebulæ and certain stars which seem associated with them. The division of the sky into regions that are starless but nebulous, and starful without nebulæ, is well worth attentive consideration. Mr. Proctor boldly affirms that "*the nebulæ, in a sense, represent the missing stars; that the region where these nebulæ appear has been drained of star-material, so to speak, in order to form them.*"

Here, then, we leave this remarkable book. It is impossible to exhibit the force of the reasoning by abbreviated statements and brief extracts; but a perusal of the work will show that the great merit we claim for its author must be conceded to him. His speculations have all the character of true philosophy. They are all tinctured, more or less, with inductive probability; and they all have the valuable property of stimulating thought, and directing inquiry into channels likely to conduct to truth.

FOREIGN SCIENCE.

AMONGST the matters of interest which have come before the French Academy in the course of the last few months are some fresh researches of M. Becquerel, "On the Production of Electro-capillary Currents in the Bones, Nerves, and Brain." He finds that these currents, which contribute to the nutrition of the tissues to which they belong, continue for some time after life has ceased. He says they do not arise from a direct action of the oxygen transported by arterial blood upon the various constituents of the organic material, which is not a conductor of electricity, but from an electromotor force resulting from contact of a liquid holding in solution the compounds produced by the action of the oxygen on the ambient liquid. He found that neutral solutions of sulphate of potash and ammonia, chloride of sodium, and nitrate of potash, placed in cracked (*felés*) tubes were negative in contact with distilled water. Distilled water coming (through the cracks) in contact with water containing fine powders of Iceland spar, quartz, mica, bone dust, etc., exhibited electro-motor force. In this case the insoluble powder appears to take alkali from the glass, and then give it to the water. In quartz vessels no current was produced. His investigations of brain currents led to the conclusion that they arise from the mutual action of the grey and white matters, the former being oxydised and the latter reduced.

Another physiological investigation which may prove useful in dietetics is that of M. L. Coutaret, who finds that maltine or vegetable diastase has a powerful digestive action on cooked starchy matters, one gramme of maltine acting on from 1,800 grammes to two kilogrammes of cookod starch.

M. O. Liebreich details experiments which may prove important in cases of overdose of chloroform, chloral, etc. He found that rabbits, poisoned with these substances by two gramme doses, recovered by injecting one and a half milligrammes of strychnine. Soon after the publication of M. Liebreich's observations M. Verneuil stated that a mason suffering from traumatis tetanus had been successfully treated with subcutaneous injections of hydro-chlorate of morphia and chloral internally. M. Verneuil pointed out the need of further experiments, and M. Nélaton stated that tetanus was sometimes removed by various methods, and at others resisted all, so that nothing could be predicated from a few cures.

A little while ago M. Flamintzin stated that starch in plants was developed specially under the influence of blue light, but M. Edouard

Prillieux finds that the same action which takes place under the blue or violet rays, if the illumination is sufficient.

The pleasant odour emitted by fir trees in a sunny atmosphere has long been thought serviceable to invalids, and the vicinity of pine woods has been deemed salubrious. It appears that the *Eucalyptus globulus* of Tasmania, which grows to more than two hundred feet in height, has been supposed to exert a like beneficial effect, and M. Romel has naturalised it for this purpose on the Mediterranean shore. It was tried in Paris but did not endure the winter cold. M. Cloez has obtained from the wood an essential oil, which he names Eucalyptal; $C^{25}\ H^{20}\ O^2$ represents its composition, and it belongs to the same series as camphor.

M. Bouley has been studying the statistics of hydrophobia obtained from various districts in France, and he states that of 320 persons bitten by mad dogs about 38 per cent. escaped serious consequences. The rate of mortality was lowest when the number of accidents was greatest. This may arise from many dogs having been wrongfully supposed mad, and the evidence is altogether lessened in value for want of proof that the disease really existed, as stated by the local authorities. March, April, and May gave 89 cases; June, July, and August, 74; September, October, and November, 64; December, January, and February, 75. This conforms with other experience, and shows the folly of tormenting innocent dogs with muzzles in hot weather, as enforced by the late Sir R. Mayne. In fatal cases death usually ensued within the first four days. Cauterization, especially with red hot iron, seemed the most effective remedy. Out of 134 cauterized cases 92 escaped; out of 66 non-cauterized the mortality was 56.

A course of investigation by M. Houzeau on ozone confirms the conclusions of Schönbein and Andrews that ozone really exists in the atmosphere, especially in the country. He prepares ozone by a new method which consists in agitating a mixture of cold concentrated sulphuric acid, and perfectly pure binoxyde of barium. The oxygen disengaged under these conditions has the ozone odour, and when moist blackens silver and decomposes iodide of potassium. Instead of Schönbein's iodine starch paper he uses as a test a paper of red litmus, impregnated for half its length by a solution containing one-hundredth part of neutral iodide of potassium; this part becomes blue by action of ozone. He measures the quantity of ozone by passing the gas charged with it through a graduated solution of very dilute sulphuric acid containing neutral iodide of potassium. In contact with the acid the ozone transforms the iodide of potassium

into potassia, which unites with it and iodine, which is precipitated. The iodine is expelled by boiling the liquid, and when it is cold the quantity of acid left is ascertained by neutralising it with a graduated lime solution.

The existence of selenium in the copper of commerce has been ascertained by M. Ch. Violette. The specimens he operated upon were believed to have been extracted from Chilian ores. He considers that some errors may have been introduced into organic analysis from the presence of the oxide of this metal in the oxide of copper which is employed. To this he ascribes the acid reaction of the water obtained in organic analysis.

Amongst recent French contributions to geology may be noticed the researches of M. Alphonse Milne-Edwards amongst the fossils of the Bourbonnais. He finds in the tertiary deposits of St. Geraud-le-Puy and of Lanzy, intertropical characteristics, such as paraquets, curucus, salanganes, gangas, marabous, and secretaries.

M. Richard has discovered relics of the so-called stone age in Arabia and Egypt. At the foot of Mount Sinai, in hillocks of yellow clay and lamellated gypsum, he dug up what he calls flint hammers (*marteaux*), and knives (*couteaux*) in great numbers, together with arrow-heads and tortoise-shaped pieces.

Near Cairo, in the vicinity of the petrified forest, he found implements of sandstone (*gres petrifié*), and at Thebes, near the tombs, many stone implements.

M. A. Leymeric calls attention to the broken fragmentary condition of the high peaks of the Pyrenees. He states that most of the peaks exhibit rocks in chaotic ruin, and that masses of living rock were exceptions.

M. Deuza describes a storm on Feb. 13, which carried dust from Africa, mingled with rain, over a great part of Italy. In the northern parts there was a heavy fall of red snow, which was coloured by the sand.

Our readers will remember the interesting paper on birds' nests, by Mr. Wallace, which we published some time since, wherein he showed that certain birds exercise their reason and improve their habitations when new materials or fresh conditions are offered to them. M. Pouchet confirms these views, and shows that the swallows of Rouen now build more roomy nests, with more convenient entrances than formerly. He says, "The new nests, instead of affecting the globular form, represent the quarter of a hollow demi-ovoid, having its poles much elongated, and with three sections adhering to the walls of the buildings against which

they are erected." The notion that swallows always build alike is certainly incorrect. Mr. Slack states that at his house in Sussex three swallows'-nests were built near together—two under straight horizontal eaves close to a window, and another at the point of a gable. The two first are somewhat flattened hemispheres, with pretty large horizontal openings just under the woodwork of the eaves. The third is more pear-shaped, with the elongated end downwards, and acting as a pillar of support. The entrance in this slants to the north-east, the woodwork protects it to a considerable extent against the entrance of wind, and this side was apparently selected on account of the violence of western gales, or possibly as being more out of the afternoon sun.

The mouths of the two nests were found damaged on the arrival of the birds this season, and they repaired them with strongly-thickened rims. They carried on their operations without any hesitation, though bricklayers had a ladder on the roof, and were at work within reach of the nests.

On the 12th of April, M. G. Rayet, while examining with a spectroscope an immense sun spot, saw the line C reversed, and became luminous in the portion answering to the nucleus. He remarks that he only knows of one similar case, recorded by Secchi on the same day two years before (April 12, 1869).

On the 19th of April, M. Delaunay states that a new planet was discovered by M. Borelli at the Observatory, Marseilles. It was between 12 and 13 mag., and is to be called Lydia. It is the 110th now known of the group between Mars and Jupiter.

Father Secchi describes the spectroscopic examination of a large solar spot on the 4th of April. He describes two methods of viewing solar protuberances. "One consists in employing a magnified solar image and a narrow slit, the other a small image and a wider slit. Both have their advantages. The second method acquaints us with the form of the protuberances, while the other is better adapted to the analysis of the different rays." He describes the great spot on the 4th of April as crowned by a very bright protuberance, and surmounted by a very brilliant cloud (*nuage*) composed of the elongated and juxtaposed bodies. This persisted with little change of form from nine a.m. to three p.m., and a trace was visible the next day. "The cloud was accompanied below by a very bright chromosphere: the rays of hydrogen penetrated the solar disk, and appeared very bright on the faculæ, which divided the nuclei." The light of the protuberance was sparkling, and exhibited the appearance mentioned by Lockyer, and often seen by

Secchi, the ray C seeming double. This, and similar phenomena, he ascribes to the fluctuation of our atmosphere. He also noticed many times, while viewing the cloud and protuberance, "the bright red line projecting itself, not on the black line of the exterior solar atmosphere, but wholly on the most refrangible luminous side, having a black line on the side of the extreme red." This he considers to arise from the velocity of the sun's rotation changing the refrangibility of the spectral rays.

The aurora of the 5th of April appears to have been extensively observed in France and Italy, and M. Soniel speaks of a disagreeable gaseous smell in a mist at Paris at the time.

To revert to a subject of natural history, M. N. Joly describes a rotation of the embryo in the eggs of the axalotl similar to that well known in the eggs of water snails.

PANDORINA.—Pringsheim has recently communicated some interesting observations on this fresh-water Alga, to the Academy of Berlin. It is a member of the *Volvocineæ*, and each of its cells is ciliated throughout life,—a fact which has led to its customary classification among animals. Pandorina generally consists of sixteen sphenoidal cells (the base of each wedge being turned outwards), and these, together with their connective tissue, completely occupy the space which the envelope of the plant encloses. Each cell has on the outer side a spot from which the cilia proceed and penetrate the envelope; and near this is a granule of red pigment, which Ehrenberg termed the eye. The plant is propagated both sexually and asexually. In the latter case, each of the original cells splits up into sixteen others, which remain united to each other and also, for some time, to the gelatinous envelope, which eventually dissolves, thereby setting them free. In the former case, some abnormal phenomena present themselves. A new plant is formed as before, but its cells are turned to account only as a means of sexual reproduction; the common membrane dissolves more slowly, and the cells remain longer in groups. At length, however, they separate as individual spores (*schwärmsporen*). Each of these spores, like all Pandorina cells and most spores of Algæ which contain chlorophyll, have a colourless spot in front, from which cilia proceed, and a red pigment granule beside it. Pairs of spores unite, always at the points of ciliation, at which they remain in contact, and eventually blend to a permanent *oospore*. No clear difference of sex can be discerned in the pairs of spores; and they vary much in size. The oospores germinate when placed in water after drying, their contents yielding, as a rule, but a single spore, seldom two or three spores; and these undergo fission, each

into sixteen cellules, which unite to form one Pandorina plant. Pringsheim considers the spermatozoids and impregnatory globules of Algæ to be modified "spores," traces their analogues among phanerogams and cryptogams, and broadly states that the outline of all reproductive bodies in plants is the germ of this spore.

FUNCTIONS OF STOMATA.—It was demonstrated by Von Mohl, in the year 1856, that stomata are the subjects of a periodic movement, opening in the daytime and closing at night. Czech has resumed the study of this subject, and finds that Mohl's conclusion is true for those stomata only which occupy the green parts of plants. These he has always observed to be wide open at midday; the aperture, however, being less extended when acted on by merely reflected light, or in dull and cloudy weather. Experiments with a hyacinth showed that the medium-sized stomata of that plant require fifty minutes for complete opening or shutting. On the other hand, it was found that the stomata of those parts of plants which had other tints than green were unaffected even by intense sunlight; nor has light any influence on the green parts of an Aspidistra which grows in the shade. Hence Czech infers that the stomata or parts that are not green, are always closed; they probably are limited in their functions to an exchanging of gases.

Stomata belonging to the green parts of plants have an additional function to perform, namely, that of aqueous transpiration. It seems reasonable to anticipate that, if we take two species belonging to a single genus, one being a plant with a dry habitat, another prefering a moist locality, the latter will have relatively the greater number of stomata. By taking into account the upper as well as the under side of the leaves, and adopting a square millimeter as the unit of comparison, Czech has verified his deduction. The genera examined were *Populus, Brassica, Solanum, Pinus, Betula, Quercus.*

SPECTRUM OF *Elater noctilucus.*—According to the observations of Professor Young, the light from this insect furnishes a continuous spectrum, without a trace of bright or dark lines. The spectrum lies almost wholly between the Fraunhofer's lines C and F, where thermic and active influences are at a minimum, nearly the whole of the rays being devoted to luminous effects. Artificial light has not yet succeeded in equalling this economy.

STELLAR PHOTOGRAPHY.—Remarkable success has been met with in this department of photography by Rutherford. Having a very superior objective at his command, he has been enabled to photograph several groups of stars, more especially the Pleiades, an exposure of

three to four minutes being frequently sufficient for the purpose. With the help of a micrometer of his own construction, he has measured the distances between these stars, and has compared the results with Bessel's astronomical determinations. The agreement is extraordinary, and serves to establish the photographic method on the one hand, while, on the other, it confirms Bessel's numbers. It also proves that the members of the group referred to have not altered their relative distances for a quarter of a century.

Velocity of Sound in Pipes.—This subject has recently been investigated afresh by Seebeck, whose results are not quite in accordance with those of previous experimenters. He finds that the velocity of sound in pipes is always smaller than in an unconfined space, and so far depends (1) on the inner surface of the pipe; (2) on the magnitude of the pipe's section, the loss of velocity (in narrow tubes, at least) being inversely proportional to the diameter; and (3) on the pitch, the loss being smaller as the pitch diminishes.

Vitriol Manufacture.—In this manufacture, sulphuric dioxide (which is produced by burning sulphur or a sulphide in air) is conducted into a series of leaden chambers, where, by the joint action of air, steam, and vapour of hydric nitrate, oil of vitriol is formed. According to theory, the action of hydric nitrate (or rather nitric peroxide, which it yields under these conditions) is *continuous*, that is, a given amount of nitric peroxide can convert any quantity of sulphuric dioxide, however great, into oil of vitriol. Practically, more nitrate has to be applied from time to time.

P. W. Hofmann has explained the difficulty. When very little water is present, nothing but the well-known "lead-chamber crystals" is formed, and no oil of vitriol. When more water is present nitric peroxide acts continuously, in accordance with theory; when still more water accumulates, the nitric peroxide is transformed into nitrous oxide, which is not oxidised by air, and therefore cannot act continuously. Hofmann recommends using a medium amount of water, so that the oil of vitriol formed never has a lower specific gravity than 60° Baumé. In this way he has already succeeded in reducing the nitrate to 1 per cent. of the yield of vitriol.

MAN AND NATURAL SELECTION.*

Mr. Wallace has just published an interesting collection of Essays written at various times for periodicals, our own amongst the number, and he enters upon the curious question of natural selection considered in reference to its action upon the development of the human race.

It is constantly necessary, in speaking of Darwin's great doctrine, to guard against the notion that natural selection alone can be the *origin* of species; and we wonder that so acute a thinker as Mr. Wallace should actually name a series of propositions, which he has arranged in logical order, "A Demonstration of the Origin of Species by Natural Selection." If Darwinianism be true, we have first, organic life with powers of reproduction and variation; then the operation of surrounding conditions killing off those least able to conform to the circumstances under which they must live or die; and finally the "survival of the fittest," to use Herbert Spencer's happy term. The perpetual repetition of these processess may easily give rise to so-called "species" which are only varieties capable of hereditary procreation within certain limits. To get at a real *origin* of species, supposing these are the methods of operation, we must arrive at the cause of descent with variation, and at the cause of such co-ordinations of circumstances as will account for the highly complex, and yet orderly arrangement which science traces in the universe around us. There is a sense in which a spark is the cause of an explosion; but if we are told that a house was blown up because a spark fell upon its floor, we inquire what combustible and explosive material was thereupon deposited, and we only assign to the spark the power of determining one of many conditions by which the result was produced.

Mr. Darwin has shown, with a marvellous fullness of fact and illustration, how natural selection *influences* or determines the formation of species; and from the Essays before us it is evident that Mr. Wallace, by independent thought and investigation, had arrived at very similar conclusions, but no philosopher has yet traced many of the most important steps.

Certain difficulties connected with the operation of the Darwinian law come out very forcibly when attempt is made to apply it to the development of the human race, and with them Mr. Wallace

* "Contributions to the Theory of Natural Selection;" a series of Essays by Alfred Russell Wallace, Author of "The Malay Archipelago," etc, etc. Macmillan and Co.

endeavours to deal. He shows, first, how certain kinds of mental and moral development which favour co-operation and division of labour, would enable a more developed race to beat a less developed one in the battle of life. He considers that "man was a homogenous race at a very remote period of his history—a period of which we have as yet discovered no remains, one so far off that he had not yet acquired that wonderfully developed brain, the organ of the mind, which now, even in his lowest examples raises him far above the highest of brutes." At this remote era Mr. Wallace's man had not acquired "human speech, nor those sympathetic and moral feelings which in a greater or less degree everywhere distinguish the race."

Man's intelligence and capacity for combination, give him a power of using, or resisting, external circumstances to an extent far greater than that possessed by any other creature, and there is no reason to suppose that "natural selection," will ever change him into anything substantially different from what he is.

In considering the limits of the action of natural selection in man, Mr. Wallace calls attention to the very significant fact that while the brain of the lowest savages probably averages five-sixths of the size of the brain of civilized man, the brain of the anthropoid apes scarcely amounts to one-third of that of man. Thus man in a very low condition appears to possess a sort of reserved force of brain which does not come into operation until civilization acts upon him, except so far as to render the first steps of civilization possible. The lives of the lower savages exhibit little advance upon those of brutes—"a brain slightly larger than that of the gorilla would have sufficed for the limited development of the savage," and "we must therefore admit," says Mr. Wallace, "that the large brain he actually possesses could never have been solely developed by any of those laws of evolution, whose essence is that they lead to a degree of organization exactly proportionate to the wants of each species, and never beyond those wants." Undeveloped man no doubt exhibits capacities beyond his attainments, but if higher species are developed by descent with variation, natural selection, etc., from lower, is not this the case all through? Does not the experience gained by man in taming and teaching a variety of creatures point to the same fact, and does not nature bestow upon all the highly organized creatures, if not upon lower ones, a brain power beyond what they habitually use?

"The brain of prehistoric and savage man," exclaims Mr. Wallace, "seems to me to prove the existence of some power,

distinct from that which has guided the development of the lower animals through their ever varying process of being." The existence of a power superior to that of all the so-called secondary causes may be more clearly traceable in man's development than in that of the lower animals, but the superior power is surely to be recognized in all regions and in all directions, and it is a grave logical and metaphysical mistake to suppose that secondary causes suffice, without constant reference to a primary cause to explain what exists.

Mr. Wallace thinks that natural selection could never have given civilized man a hairless body, as all savages exposed to cold or wet, adopt a covering for the back, and hair in that position would be advantageous to them, and that we cannot suppose the absence of hair on the body to be correllated with development of the brain, but why not? Correllations do not stand to each other as cause and effect, and if throughout nature we find vast numbers of correlations useful or beneficial, why should we hesitate to recognize an intelligent cause? We quite agree with Mr. Wallace in his deductions, that a power other than natural selection is demonstrated by the facts pertaining to man, but we think all that the appearance of man upon the scene does is to confirm and extend proofs of an analogous kind that would be drawn from the lower world. Doubtless the universe contains beings higher than man, and if we knew their nature and development we should expect a more striking proof of the same ultimate fact.

Mr. Wallace finds it impossible to believe that the "intense and mystical feeling of right and wrong," which man exhibits can be the mere result of accumulated ancestral experience of the utility of moral sentiments and so forth, and others will feel the same difficulty. "Natural selection" alone could not account for such results, but its operation, though of great importance, is limited all through its sphere of action, and we see no region in which there is not a logical necessity for an Intelligent First Cause. Mr. Wallace winds up his arguments by commenting on the difficulties of proving the existence of matter, and the probability that *will* is the great ultimate force.

Man is subject like other creatures to the incidents which give rise to natural selection. His power of multiplication and the difficulty of procuring food brings about a battle for life, and the weaker races perish in collision with the strong. A premature development of moral or æsthetic faculties only helps to make the race that grows in this direction the prey of another which unites

strong animal instincts with the human capacity for organization. At last a point is reached in which the gentler side of life may be cultivated without peril, and when the sword can be safely beaten into the ploughshare; natural selection may favour races remarkable for benevolence, but it will not let "the ape or tiger die" while their qualities are in demand.

ON THE STRUCTURE OF PINNULARIÆ.

BY HENRY J. SLACK, F.G.S., SEC. R.M.S.

WELL knowing the objections to publishing incomplete investigations, I yet think it desirable to call the attention of microscopists to some appearances I have just noticed in various diatoms of the genus *Pinnularia*, with a view to enlist their co-operation in a fresh investigation of these objects.

It is usual to assume that the *Pinnulariæ* (Sm.) are distinguished from *Naviculæ* by the presence of costæ, or ribs, not divisible into beads. Some time ago, when examining a fine Möller's type slide, which Mr. Curteis (of Baker's) obtained for me, I was much struck with the gradual transition from rows of beads, unmistakable with powers of $\frac{1}{4}$th and $\frac{1}{20}$th, to similar rows which the same powers showed almost in contact, quite in contact, and finally to so-called costæ, or ribs. Beck's $\frac{1}{20}$th, from its moderate angle of aperture, is far better adapted to many physiological and natural history purposes than a larger-angled glass, but it was only reasonable to expect that one of the latter construction would resolve many rows that might look like ribs to the former.

I have just been viewing the so-called *Pinnulariæ* in Möller's slide (he ranges them under the head of *Naviculæ*), with Powell and Lealand's new and very remarkable $\frac{1}{8}$th, using the immersion front. I find the so-called costæ of many species, resolvable into beads—some plainly, others only in an indicatory way. I hope to resume the subject by-and-by. *P. acuminata, hemiptera, Brebissoni, borealis, gibba, do. forema gracilis mesolepta,* and others, were found most manageable. I used the $\frac{1}{8}$th with Ross's D eye-piece.

I will now ask the opinion of microscopists on another point. If *P. nobilis, major,* or *viridis,* is illuminated with unilateral light, either by Reade's prism, or, what I prefer, a single radial slot in a large-angled condenser, and power from $\frac{1}{2}$ inch, with a deep eye-piece, up to $\frac{1}{8}$th or $\frac{1}{20}$th, are employed, on focussing downward the

so-called costæ appear as fingers laid on the surface of the diatom, and this is, I believe, the usual reading; but, especially with the immersion $\frac{1}{8}$th, a much sharper definition is obtained by focussing a trifle lower, when, instead of thick fingers, delicate ribs are seen proceeding from the median band. Two of these delicate ribs, with the interspace, make one of the finger-like costæ seen the first way. Perhaps they are seen most easily when the single pencil of light is sent up between them towards the median band; but it is instructive to try a cross light from left to right, and then *vice versa*, noting the change in the position of the shadows.

With this focussing and illumination the ribs do not look as finger-shaped objects placed upon the diatom, but as slender prolongations from the median band. The ribs make loops where they join the median band, the whole appearance being like a series of narrow arches surmounting long thin shafts.

In using Möller's slide to investigate unknown objects, I find it handy to adjust for thickness of the covering glass upon the *N. rhomboides*, which, notwithstanding the Canada balsam employed, allows both sets of lines to be seen. This is the case with my slide, and with another kindly lent me by Mr. Curteis.

Powell and Lealand's new $\frac{1}{8}$th is remarkable for its chromatic as well as its spherical corrections. It gives a sharper definition than any of their elder patterns which I have seen, and is free from the chromatic errors that used to be thought inseparable from very clear definition. It is certainly a splendid triumph of optical art.

TELESCOPIC WORK FOR MOONLIGHT EVENINGS.

BY W. R. BIRT, F.R.A.S.

AN interesting lunar region, that has been very inadequately described, is found on the northern hemisphere of the Moon, between the well-known spot Plato and the lowest edge or limb of the Moon as seen in an inverting telescope. This region, which is situated between the craters Fontenelle, Timæus, and Epigenes, of Beer and Mädler, comes into sunlight about and just after the first quarter. Beer and Mädler speak of it as calculated to "throw the observer into the highest astonishment," and certainly as the Sun rises upon it and illuminates one after another the ridges of mountains which compose it, it is a magnificent spectacle. The three leading objects, the craters above-named, which may easily be found by means of Webb's index map in his "Celestial Objects for Common Telescopes," are the three angular points of the region. It is naturally divided into two distinct areas, and is bounded on the south by the Mare Frigoris. The western division consists of very rugged land, the principal feature being a bold promontory, more or less cleft, which stretches into the Mare Frigoris towards Plato. Between the rugged land on the west, and a very individualized depressed surface on the east, a sinuous mountain-chain extends from the promontory above-named to the fine bold eastern portion of the rim of Epigenes. This crater is an interesting instance of a feature by no means uncommon on the Moon, viz., portions of walled plains occurring in extensive lines of cliffs or mountains. In many instances the cliffs are interrupted or broken, so as to form extensive bays on the surfaces of the plains and bold promontories at the points of their inosculation. The west border of Epigenes forms a portion of another range, west of and nearly parallel with the before-mentioned chain of mountains. The western range rises to a considerable altitude on the west border of Epigenes, and is continued to a high mountain at the west end of a fine walled plain just west of the crater Anaxagoras. This plain is surrounded by high mountains, and is by far the grandest and most imposing object in this lunar landscape. It remained unnamed until the late Dr. Lee suggested the designation "GOLDSCHMIDT" as suitable for it. The eastern division of this region—which, as before stated, consists of a depressed surface—is not much raised above the surface of the Mare Frigoris on the south. The N.E. boundary forms a separation between two levels, as if a "fault" had occurred in the line between Fontenelle and Epigenes.

The lower level, which has upon it two short mountain arms stretching outwards from the N.E. boundary of the depressed surface, extends towards Anaxagoras, and is generally smooth. There is in its neighbourhood a well-marked crater forming a triangle with the N.E. angle of the depressed surface east of the rugged land and Fontenelle. Between this crater and Fontenelle an imperfect elliptical depression exists, and another may be noticed to the N.E. of this. Between the craters Timæus, Fontenelle, and Anaxagoras, the observer will find three very distinctly marked and individualized formations, viz., the rugged land west of the mountain chain passing through the east border of Epigenes; the depressed surface on the east of the same mountain chain (the interior of this depressed surface contains several interesting objects); the third formation is the depressed surface extending towards Anaxagoras. To trace out these features, to observe during the progress of the illumination of the northern parts of the Moon's disk the changes in aspect which they undergo as the Sun rises higher above them, and as that hitherto unexplained and mysterious metamorphosis, which so gradually creeps over the surface, obliterating some objects and bringing out others not seen before, passes through its various phases, together with the gradual streaking of the landscape with the rays from Anaxagoras, form a pleasing and instructive occupation with the telescope while the Moon is passing from her first quarter to full; and to those students who prolong their watchings to "early dawn," the formations seen under the reverse light are full of interest.

GLANCES AT NEW BOOKS.

THE REV. WILLIAM ALLEN WHITWORTH, has recently issued a second edition of his clever book on "Choice and Change,"* supplying a valuable and highly amusing treatise on probabilities applied to a great number of matters of general interest, games of chance, possibilities of choice, etc., etc.

From the pen of Mr. George Catlin we have a strange little book solemnly recommending men to "Shut their Mouths and Save their Lives."† The same author brings before us a work on "The Lifted and Subsided Rocks of America, with their influence on the Oceanic, Atmospheric, and Land Currents; and the Distribution of Races."‡ Mr. Catlin during his travels met with some instances and many indications of subterranean waters under the Rocky Mountains and the Andes, and from these circumstances he makes a bold jump to a theory of the Gulf Stream, which he fancies to indicate the existence of a river "many times larger than the Mississippi and nearly twice the Mississippi's length, gliding through the clear and vast rocky cellars of the upheaved mountains," and at last reaching the Gulf of Mexico. "Through the heated vaults underneath the Andes," he "contemplates a similar river running from near the thirtieth degree S. lat. to the north, and conveying their overflowing waters also into the Caribbean sea." Speaking of the Indian races he points out that their traditions of the creation of man do not seem derived from the Mosaic account. "The Choctaws assert that they were created crawfish, living alternately under the ground or above it as they chose, and coming out of their little holes to get the warmth of the sun one sunny day, a portion of the tribe was driven away and could not return. These built the Choctaw villages, and the remainder of the tribe are still underground. The Sioux relate with great minuteness their traditions of the creation. They say that the Indians were all made from the red pipe-stone, which is exactly of their colour. Other tribes were created under the water, and at least one-half the tribes

* "Choice and Change," by the Rev. William Allen Whitworth, M.A., Fellow of St. John's Coll., Cambridge. Second Edition, enlarged. (Cambridge, Deighton, Bell, and Co.; London, Bell and Daldy.)

† "Shut your Mouth and Save your Life," by George Catlin, author of "Notes of Travel amongst the North American Indians," etc., etc. With 29 Illustrations from drawings by the author. Fourth Edition, considerably enlarged. (Trübner and Co.)

‡ "The Lifted and Subsided Rocks of America, with their influence on the Oceanic, Atmospheric, and Land Currents; and the Distribution of Races," by George Catlin. (Trübner and Co.)

in America represent that man was first created underground, or in the rocky caverns of the mountains."

Rev. W. Mattieu Williams, F.C.S., has produced a very painstaking essay on the "Fuel of the Sun,"* but we fear scientific men will find his reasoning vitiated by some fundamental misconceptions. He estimates the pressure of the sun's atmosphere at his surface as equal to more than fifteen thousand of our atmospheres and reckons upon an enormous heat being the result of the compression of the lower strata. This heat he conceives would produce dissociation of water, etc., and that action would give rise to cooling. Now it is evident that we must not deal with the sun's atmosphere as if we had a mass of cold rarified gases which we could condense by the application of the pressure supposed, and what would happen in the way of dissociation under such gigantic pressure we do not know. The author thinks the sun is not so hot as physicists suppose, and he imagines solar heat maintained by a constant condensation of the atmosphere of space. He imagines the sun, as he passes through space, leaving a friction trail behind him, and compensating himself by attracting matter in front of him, the condensation of which would evolve heat. If we understand his theory he supposes that the intensity of solar heat may result from the radiation of lower degrees of intensity from successive layers, each outer one permitting the passage of heat from those below it. The heat of several layers of *the same intensity* being conceived to combine and produce a heat of greater intensity. If we could raise temperature by adding heat in this way, a sufficient number of surfaces radiating boiling water heat ought to melt iron. If in this and in other particulars physicists will totally differ from the author, we cannot but regret that he should have expended so much talent and ingenuity as his book evinces upon a disscussion destitute of sufficient basis in logic and fact.

Mr. Josiah Miller, M.A., makes a bold attempt to exhibit the "Inductive Method in Scripture and Science,"† and Dr. J. H. Gladstone supplies a preface. Neither of these gentlemen seem to have any idea of the immense range of inquiry when theological belief, the authority of sacred books, etc., etc., is to be investigated scientifically. They assume what they ought to prove, and Mr. Miller speaks of an "inductive inquirer," "beginning with

* "The Fuel of the Sun," by W. Mattieu Williams, F.C.S., author of "Through Norway with a Knapsack," etc. (Simpkin, Marshall, and Co.)

† "Christianum Organum; or, the Inductive Method in Scripture and Science," by Josiah Miller, M.A., author of "Singers and Songs of the Church," etc., with an introduction by John Hall Gladstone, Ph.D., F.R.S. (Longmans.)

putting faith in the Scriptures as God's Revelation." He might as well propose an inductive inquiry into the movement of celestial bodies and then require, as a first step, faith in the laws enunciated by Kepler and Newton. Deduction plays as important a part in most comprehensive investigations as induction, but whichever method be adopted, scientific rules require that nothing shall be taken for granted that is not self-evident or axiomatic.

Mr. A. Pettigrew comes to aid families living in the country with a "Handy Book about Bees."* We should recommend this book as an addition to, rather than a substitute for the well-known "Bee-Keeper's Manual,"† by Henry Taylor, which still remains the best authority on the subject. Mr. Pettigrew recommends a little known anæsthetic for stupifying bees, in the shape of a fragment of old corduroy or fustian breeches! He speaks very highly of its action, and says his father used fustian smoke nearly 70 years ago. The directions to the bee-keeper are simple enough, "Get a piece (of old worn-out fustian or corduroy) the size of a man's hand, rolled up rather tight, and fired at one end, not to blaze, but simply to smoke. Let him now place the smoking end so close to the door of a hive that all the smoke may go in when he blows on it. After six or eight puffs have been sent into a hive, let him lift it off the board, turn it gently upside down, so that the bees and combs stare him in the face. By holding and moving the smoking end of the rags over the face of the bees, and blowing the smoke amongst them, they run helter skelter down amongst the combs, far more afraid than hurt. Now he can carry the hive round his garden under his arm, and round the house and over it too if he chooses, without being stung. Whenever the bees are likely to rise, they should be dosed again."

Mr. Pettigrew is strongly in favour of large hives, holding from 100 to 168 lbs. of comb and honey. He says, "straw hives well sewed with split canes or bramble briars are incomparably better for bees than any other kind of hive yet introduced." Most practical bee-keepers will confirm this opinion, and the ridiculously expensive, complicated contrivances which many people have been persuaded to employ has greatly tended to diminish bee-keeping, and sicken them of a pursuit they would have followed steadily had they not been misled. The "Handy Book" gives plain directions about managing bees at various seasons, hiving swarms, taking honey,

* "The Handy Book of Bees." Being a Practical Treatise on their Profitable Management, by A. Pettigrew. (Blackwood and Sons.)

† Groombridge and Sons.

and using the various appliances, "ekes," "supers," "nadirs," etc., required for the new swarming system. Like Mr. Taylor the author recommends simple methods, and protests against many stupid practices common in villages, and continued without reason from one generation to another.

Mr. Thomas Twining has issued a "Memorandum," which he calls "Science for the People,"* explaining his praiseworthy and successful efforts to popularize elementary scientific knowledge by lectures, which he causes to be read by one of his assistants, and experimentally illustrated by another. The lectures themselves will, we suppose, from his remarks, shortly appear.

Dr. Arnott contributes to the education cause a short essay entitled "Observations on National Education,"† in which amongst other desirable things he advocates giving fair play to the culture of girls.

Mr. Rupert Jones continues his valuable labours in editing the "Reliquiæ Aquitanicæ"‡ and the tenth part recently issued contains an interesting essay by M. E. Lartet on "the employment of Sewing Needles in Ancient Times." The Ancient Egyptians had well-made bronze needles with eyes much like our own, and in this work a piece of sandstone from the Cave of Massat, is grooved as if used to grind the bone needles to a proper size and form. The old cave folks pierced their needles with eyes of which figures are given, and if they broke a long needle they made it into a shorter one.

The plates accompanying this part are as excellent as usual, and the bone implements figured exhibit various kinds of simple ornamentation and rude outlines of figures. Some of the patterns are by no means destitute of taste, and one exhibits a pleasing combination of flowing curves.

Mr. Donovan has published a "Handbook of Phrenology."|| It

* "Science for the People. A Memorandum of various means for Propagating Scientific and Practical Knowledge among the Working Classes, and for thus Promoting their Physical, Technical, and Social Improvements," by Thomas Twining. (C. Goodman.)

† "Observations on Fundamental Principles, and some existing Defects of National Education." By Niel Arnott, M.D., F.R.S., etc., Member of the Senate of the London University. New Edition, revised, with additions. (Longmans.)

‡ "Reliquiæ Aquitanicæ. Being contributions to the Archæology and Paleontology of Perigord, and the adjoining Provinces of Southern France." By Edouard Lartet, and Henry Christy. Edited by Rupert Jones, Prof. of Geology, etc., Royal Military College, Sandhurst. Part X. (Bailieré.)

|| "A Handbook of Phrenology." By C. Donovan, Professional Phrenologist, Doctor of Philosophy, Fellow of the Ethnological Society, etc. With Illustrations. (Longmans.)

is intended as a popular introduction to the practical use of the science (?). That those physiologists who have derided Phrenology have neglected the due consideration of a large amount of important fact is obvious to all unprejudiced inquirers, but the Phrenologist of to-day should fairly consider all the objections to his scheme that are made by either physiologists or metaphysicians. Dr. Donovan does not undertake any such task and his work does not contribute to any advance in scientific thought.

A new and much wanted edition of Shirley Hibberd's "Rustic Adornments for Homes of Taste,"* has just been issued in a larger and much handsomer form than its predecessors. Mr. Hibberd is unequalled for the tact and skill with which he indoctrinates the public with sound knowledge and good taste in all matters pertaining to gardening, floral decoration, and a host of kindred subjects that he has made his own. Much of his success arises from the fact that he is no mere compiler of books from other men's materials, but a keen active worker and experimenter with a decided genius for his pet avocations. The new edition of "Rustic Adornments" is to a large extent rewritten, and contains much new matter. It forms a very handsome splendidly illustrated volume which the occupant of the town villa and the country house will not be able to see without buying, and cannot read without obtaining an invaluable amount of suggestion for ferneries, aquariums, pleasure grounds, window decoration, and what not.

Our readers will be glad to know that Mr. Proctor's new and admirable series of Star Maps can be had of Messrs. Longman. We are also glad to find that Mr. Llewellynn Jewitt is ready to receive subscriptions for a new "History of Derbyshire" which no one can be more competent to write.

Mr. Charles O. Groom Napier (of Merchiston), comes again before the public with a very curious treatise, "The Book of Nature and the Book of Man,"† with a commendatory preface in the shape of a letter to the author from the late Lord Brougham.

Mr. Groom Napier describes a variety of natural objects and draws whimsical and fanciful comparisons in which a profound philosophy is supposed to lie. Thus "phosphorescent mushrooms"

* "Rustic Adornments for Homes of Taste." By Shirley Hibberd. A new Edition, revised, corrected, and enlarged. With 9 Coloured Plates, and 230 Wood Engravings. (Groombridge and Sons.)

† "The Book of Nature and the Book of Man; in which Man is accepted as the Type of Creation—the Great Pivot on which all lower forms turn." By Charles O. Groom Napier (of Merchiston), F.L.S., F.A.S.L.. With a preface by the late Lord Brougham. Illustrated with Photographs and numerous Wood Cuts. (J. C. Hotten,)

are "like brilliant insects" the type of true genius; "human mushrooms despise one another;" "tannin one of the most important contents of oak gall excresences is astringent; the most powerful in general use having a binding influence on the body of man. This the great nation of the Gauls exercises in Europe. And why?—because their astringency causes them to be dreaded." Those who wish for a handsomely illustrated work filled with matter of this description will find themselves accommodated in, "the Book of Nature and the Book of Man."

The "Floral World" continues its useful course. The June number contains a "figure of the Rev. H. Dombrain," but if the reader expects a portrait of a clergyman in full canonicals he will be greatly surprised at finding his reverence to be a magnificent rose illustrating a paper on the cultivation of the favourite flower in all its varieties. The practical tone of the Floral World, always exactly in time with its advice and information, is a great source of its popularity.

Mr. F. V. Hayden, United States Geologist, has concluded his "Preliminary Field Report of the United States Geological Survey of Colorado, and New Mexico," and it has been recently issued by the government printing office, Washington. Mr. Hayden has also favoured us with his "Geological Report of the Exploration of the Yellow Stone and Missouri Rivers," made in 1859—60. Both these works contain important information, the former especially, pointing to large supplies of coal and iron ore. Mr. Hayden believes that the "western country" during the tertiary period "was covered to a greater or less extent with a chain of brackish or fresh water lakes." Proceeding southward from Cheyenne the tertiary coal formations are passed, and these tertiary strata, he believes, "cover a far more extended area than any other group of this epoch. It is continuous southward from the Missouri valley to Colorado, interrupted only by a belt of White River beds, about two hundred yards wide." He thinks, "these beds also extend far northward into the British possessions, probably nearly or quite, to the Arctic Sea."

We must defer noticing "Researches on Diamagnetism and Magne-crystallic Action," by Professor Tyndall and the same author's "Notes on Light" (both Longmans), as also "Grave-mounds, and their Contents," by Llewellynn Jewitt (Groombridge), as our space would not allow us to do justice to them. We may mention that Messrs. Blackwood and Sons have issued another of Mr. Collins's admirable series of Ancient Classics for English Readers, the present one being "Cæsar," well edited by Anthony Trollope.

PROGRESS OF INVENTION.

Absorbing and Utilizing Noxious Gases.—The time was when the then waste gases from chemical works were allowed to escape into the air, injuring vegetation and causing inconvenience, if not injury, to the surrounding inhabitants. Now these gases are utilized, are made profitable to the manufacturers, and eminently useful to many branches of industry. Why is it that, in an undertaking of vast public convenience, a drawback to its usefulness should be allowed to remain unremedied, by which many are precluded from sharing its benefits? The tunnels of underground railways are at times so offensive that many persons will not travel through them. The sulphurous acid which contaminates them is sometimes present in such quantities as to render it very unadvisable for persons suffering from chest complaints to trust themselves in such an atmosphere, and even those who are strong and well often feel its irritating effects very painfully on the mucous membranes of their eyes and noses. We are glad to see that an invention has been patented which will, we trust, be applied to remedy this serious inconvenience. The invention, as the patentee states, has for its object the absorption of the gaseous products of combustion evolved from locomotive engine furnaces, and from other furnaces, by means of reagents with which they unite chemically, or by which they are decomposed; or by which their chemical composition is changed. The gases usually evolved from engine furnaces are sulphurous acid and carbonic acid; and these, with other volatile matters, are brought into contact with reagents which absorb or decompose them. The patentee states that the substances which he uses are some metallic oxides, either in solution or otherwise. Sodic hydrate, commonly called caustic soda, seems to be the substance on which he places the greatest reliance, although he asserts that lime in water will answer the purpose. The advantage arising from the employment of sodic hydrate is that sodic sulphite is formed, and this substance is commercially of greater value than the sodic hydrate used. The process therefore bids fair to be remunerative as well as effectual in remedying an evil. When sodic hydrate is used, it is in the form of solution, and with this solution lumps of coke are moistened which are placed in vessels, so arranged, that the products of combustion from the furnace may pass through them, in this way the sulphurous acid is not allowed to pass out into the tunnel. The specification does not state in what way the vessels are to be

arranged, but we doubt not that engineers will be willing to avail themselves of, and apply an invention which, to say the least of it, deserves the serious consideration of those interested in the success of underground railways. The inventor is Mr. Barff, 16, North Audley Street, Grosvenor Square.

CHARGING ATMOSPHERIC AIR WITH OXYGEN.—M. Jules Theodore Anatole Mallet, of Paris, has patented a process for charging air with oxygen. Its principle is founded on the different degrees of solubility of oxygen and nitrogen in water. Water absorbs forty-six thousandths of its volume of oxygen, and twenty-five thousandths only of nitrogen. When these gases are mixed, as in atmospheric air, their respective solubility should be multiplied by the proportion they occupy in the mixture. Thus atmospheric air when dissolved in pure water gives the following result—

Oxygen $0{\cdot}046 \times 0{\cdot}21 = 0{\cdot}0097$, $0{\cdot}33$
Nitrogen $0{\cdot}025 \times 0{\cdot}79 = 0{\cdot}0197$, $0{\cdot}67$

Experiments have determined the composition of air dissolved in water to be as above stated. This air already enriched if re-dissolved in water gives—

Oxygen $0{\cdot}046 \times 0{\cdot}33 = 0{\cdot}015$, $0{\cdot}48$.
Nitrogen $0{\cdot}025 \times 0{\cdot}67 = 0{\cdot}017$, $0{\cdot}52$.

By dissolving it a third time the air will contain 62 per cent., and after a fourth 75 per cent. of oxygen.

In carrying out this invention practically, the air should be forced at varying pressures, no exceeding 150 pounds per square inch, into metallic reservoirs filled with water so arranged that the air and water shall be in immediate contact. This may be done, for example, by making the vessels of great depth and injecting air in in small jets, or by employing agitators of any kind. One portion of the air becomes dissolved, and the undissolved portion returns for acting on the piston of the air pump, or other piston with which it is connected, for the purpose of regaining the power absorbed by compression. When the water has been sufficiently saturated with the gases, they are caused to pass into another receiver similar to the first. Previous to this, however, the gases pass through a pump or cylinder with piston and slide valve, which first receives their effective pressure, and then, when there is no longer an excess of pressure, forces them into the second chamber. Between the second and third chamber a pump is placed, similar to the foregoing, and the same is the case for the whole series until the last, which is provided also with a cylinder and piston for receiving the power due to the pressure that the gases will lose,

before they pass to the gasometer. By the above arrangements almost the whole power employed for compressing the gases in the water is recovered, except that necessarily expended in friction and vis inertia. With eight solutions air containing 97 per cent. of oxygen, and 3 per cent. of nitrogen or nearly pure oxygen may be obtained; but for metallurgical purposes it is sufficient to use air with 48 per cent. of oxygen obtained by two dissolutions. If the expense consequent upon the working of this method be not too great, one can hardly over estimate its advantages.

LETTER-BOXES.—Christiana Ann Bates, of George-street, Blackfriars-road, has, by a very simple arrangement, rendered it impossible for a person to abstract letters from a letter-box, or from a pillar-post. On the inside of the door a plate is fixed having a slit through it which coincides with the end of the slit through the door. To the back of this plate, and just above the top of the slit in it is fixed a rod, to which are hinged numerous spiked teeth which hang downwards at the back of the slit through the plate. These spikes will yield readily to allow a letter to drop through the slit into the box, but will prevent or put great difficulties in the way of any one attempting to withdraw it. In order to render the letter-box still more secure a row of spikes or teeth inclining downwards is fixed to the bottom of the plate just below the bottom of the slit. This apparatus is, as will be seen, applicable to pillar-boxes.

SCISSORS FOR GATHERING FLOWERS AND FRUIT.—Scissors for cutting or gathering flowers, as generally constructed, usually have one recurved, and one plain edge, being thus formed with the object that the flower may be retained by the scissors till released by the gatherer, but this has never been accomplished with any degree of certainty. The object of this invention is to overcome this defect. A spring is attached at one end to a loose bar or blade forming a holder (which will be described directly) and placed at the side, and riding on one of the blades, and at the other to its corresponding arm. The holder, as stated, lies at the side of the blade, and is provided with a flat or broad surface at its base, extending somewhat beyond the edge of the other blade, the holder being kept in position and guided by a pin or stud fixed to or inserted in its blade, and passing through a slit formed in the holder. To use the apparatus the scissors are opened in the usual way to take hold of the flower or stem of the fruit to be cut; on closing the blades, the spring presses the holder down on the stalk and holds it between its base or broad surface and the other blade; now by

bringing the cutting edges still closer together, the stem is cut, while at the same time it is held by the holder until purposely released. The inventor is Mr. James Blyde, of Sheffield.

PREPARING AND PRESERVING MEAT.—By this invention the meat is placed in a closed vessel which is exhausted of air, and with it the deleterious gases and some of the volatile constituents of the meat. After the expulsion of the deleterious gases, the meat may be packed in tins or may be further treated by causing a current of dry warm air to act upon it. The harder parts of the meat are ground to the consistency of thick mortar or putty, and the best pieces are packed in this meat pulp, or reduced meat, and the whole is pressed into a compact mass. In this way, when packed in tins, the air is perfectly excluded, and the meat being dried, Mr. Johnson, of Lincoln's-inn-fields, the inventor, says it will keep good any length of time.

COMPOSITION FOR COATING SHIPS AND BOATS.—To prevent ships and boats from fouling, a composition is made by Mr. Gardner, of Manchester, which consists of paraffine, and this may be used in the metallic crudes or metallic particles, or with poisonous substances, such as arsenic, sulphate of copper, mercury compound, etc. The paraffine can also be used in combination with creosote dissolved in heavy oils, or a compound prepared by vulcanizing paraffine with sulphur may be employed. It is, however, on the peculiar properties of the paraffine, that the inventor depends for the success of his invention.

MISCELLANOUS NOTES.

THE COLOURS OF JUPITER.—The observations on the remarkable colours displayed by Jupiter, first made by Mr. Browning, with a 12½ inch reflector, and by Mr. Slack with 6¼ of the same construction, were abundantly confirmed by other observers, and if certain peculiarities in the management of Greenwich Observatory, which always escape the notice of those engaged in the farce of annual visitation, had not stood in the way of original research, the Astronomer Royal might have had something useful to say on this subject in his report. As matters stood, he only stated that a drawing made by Mr. Carpenter, when compared with some made eight or nine years ago "negatived the idea of any change in the colour of Jupiter's belts."

At the June meeting of the Royal Astronomical Society, Mr. Browning read a short paper alluding to this remark. He pointed out that six or seven skilful observers had all seen the colours—as shown in his drawing which we published—all using reflectors. The colours had also been seen with refractors, but not so well. Mr. Browning added, "there is a singular agreement between observers who have described this phenomenon. The colour has been described as yellow, ochreish, brown, and tawny. All agree in ascribing this colour to the equatorial belt of the planet ordinarily seen of a pure, or at most of a pearly white." The Greenwich equatorial is not a first-rate instrument, and before Mr. Airy attempted to negative numerous observations made with better means, he should have carefully ascertained, or allowed some one else to ascertain, whether his telescope would give a distinct vision of the tints in question. He should also have taken care that the object was examined when the colours were visible. Much greater service to science might easily have been rendered by the Greenwich establishment if its chief officer had not resembled a still more distinguished astronomer, whose removal from a great continental observatory was found needful to secure the subordinates fair play.

STEPHENSON'S BINOCULAR MICROSCOPE.—At the June meeting of the Royal Microscopical Society, Mr. Stephenson brought forward a new and very ingenious binocular microscope, especially adapted for dissection or other manipulation. This apparatus was fixed to a Ross stand, and the tubes of the binocular are inclined at a convenient angle when the stage is horizontal. The pencil of light from the objective falls upon two right angled prisms, rounded to fit the tubes and slightly divergent. By their action two images are produced, one for either eye, and the image is reversed in a *lateral* direction. A second prism above the others,

produces an inversion in the vertical direction, and the image of the object is *erected*, and exactly corresponds with its real position. The definition is very perfect, and the light equal in each tube. The stereoscopic picture is remarkably clear, and free from error or exaggeration. This new instrument deserves the highest commendation.

We have received from Mr. Wenham, three blue ticks, apparently belonging to the genus *Ixodes*, which he found attached to the neck of a short-tailed field mouse, and, as he describes it, "in a place where the animal could scratch itself—in fact one was behind the ear." They required some force to detach them. The largest one is about 1—11″ long. The skin is tough, lead blue colour, with reddish-brown legs, terminating in two claws. Probably when Mr. Wenham discovered them, they were attached by thrusting their rostrums into the skin of the mouse, as well as by their claws. The *stigmata*, or circular reddish spots, where the trachæ open, are situated behind the legs, and are very curious microscopic objects. The principal orifice is large, and placed out of the centre, with 50 or 60 smaller orifices round it arranged in circular rows, most of them being further back than the chief orifice. Each of the smaller orifices is surrounded by others still more minute. When removed from the creature, a number of large tracheal trunks may be seen converging towards the chief orifice, and the whole apparatus is surrounded by concentric tracheal rings.

[illegible] CARPENTER

THE DEEP SEA.

PART II.—ITS BIOLOGICAL CONDITION.

BY WILLIAM B. CARPENTER, M.D., F.R.S.

(*With Two Plates.*)

It was shown in the preceding paper that the results of the inquiries made in the "Lightning" expedition of 1868, and the "Porcupine" expedition of 1869, have completely disproved a doctrine promulgated by high authority, and generally accepted by physical geographers, as to the prevalence of an uniform temperature of 39° in the Deep Seas of all regions. For it has been demonstrated that streams of Polar water in which the thermometer sinks below 30° may penetrate far into the Temperate zone, underlying, even at the moderate depth of 300 fathoms, a stratum derived from warmer regions in which the thermometer stands 20° higher; whilst it has been rendered probable that by the continual discharge of such Polar streams into the Great Oceanic basins, the temperature of the great mass of water occupying their deepest abysses is reduced to within a very few degrees of the freezing point of fresh water.

Not less complete has been the disproof afforded by recent researches of another doctrine, the general acceptance of which was partly due to the high authority of Professor Edward Forbes, its original promulgator, and partly to the ready explanation it seemed to afford of certain Geological difficulties;—that, namely, of the limitation of Animal life to a depth of about 300 fathoms.

It is not a little singular that this doctrine should have originated with the distinguished Naturalist who was the first to urge the systematic use of the dredge as an instrument of scientific investigation. Up to the time of Edward Forbes it was mainly employed for the purpose of obtaining specimens of Marine animals that inhabit depths below the range otherwise accessible to collectors; and the discovery of new species was regarded as its most important function. This, indeed, seems to have been the idea under which he himself first worked it; but as his investigations into the Marine life of our own and other seas proceeded, and the direction of his Geological studies led him to look to *the present* for the interpretation of *the past*, he came to see what an important light is thrown by the determination of the conditions of existence of the present inhabitants of the Ocean, not only on the conditions under which the extinct types that most resemble them must have lived and become fossilized, but also on the causes which must have operated

to produce that particular distribution of the Marine Fauna which is characteristic of the present or of any preceding epoch. Thus he inaugurated a new department of research recently designated Bio-Geology, and now generally recognized as the one of which the systematic prosecution is most important to the Geology of the future.

In pursuance of this inquiry, Edward Forbes not only himself diligently laboured, but also set other Naturalists to work; urging that the Dredge is for the sea-bottom what the Telescope is for the heavens, and that the results of its use have a value which is not to be measured by the number of new forms it may bring to light, but by the information they yield as to the conditions under which the fossiliferous rocks of different Geological periods have been deposited, and the disturbances they have since undergone. Having availed himself of an opportunity of carrying on his researches in the Ægean Sea, he there worked his dredge at greater depths than those which are to be found around the British Isles; and it was in the Report which he presented to the British Association in 1843, on the results of these researches and their bearing on Geological inquiry, that he promulgated the opinion that a *Zero* of Animal life would be found at a depth of about 300 fathoms. This opinion was based on a comparison of the number of species which he met with in the successive Zones of depth which he designated respectively the *Littoral* (the tract between tide-marks, or its equivalent where there is little or no tide); the *Laminarian* (or region of sea-weeds, extending from low-water mark to a depth varying in different localities, but seldom exceeding fifteen fathoms), the *Coralline* (which ranges from the termination of the laminarian to a depth of about thirty fathoms, and is characterized by the predominance of Nullipores and the scantiness of other forms of Vegetation), and the region of *Deep-Sea Corals* (so named on account of the great stony Zoophytes characteristic of it in the oceanic seas of Europe). "As we descend deeper and deeper in this region," he remarks, "its inhabitants become more and more modified, and fewer and fewer, indicating our approach towards an abyss where life is either extinguished, or exhibits but few sparks to mark its lingering presence." Edward Forbes's dredgings did not range below 230 fathoms; and as he found the number and variety of animal forms there so greatly reduced, the continuance of the same rate of reduction for 70 fathoms more would leave the sea-bed at 300 fathoms altogether untenanted, he adopted the latter depth as a *Zero* below which Animal life does not extend.

It now seems not a little remarkable that no scientific man should have adduced in opposition to this doctrine a very striking case recorded twenty-five years previously, in which living Animals had been brought up from a depth three times as great as that of Edward Forbes's Zero. This happened in the Arctic Expedition (1818) of Captain (afterwards Sir John) Ross; and is mentioned in the narrative of his "Voyage of Discovery." The present venerable President of the Royal Society, Sir Edward Sabine, who was a member of that Expedition, distinctly remembers the occurrence, and has been kind enough to furnish me with more ample particulars of it than are contained in Captain Ross's narrative. A Sounding taken in Lat. 73° 37′ N., Long. 75° 25′ W. (near the head of Baffin's Bay), about two miles off shore, gave a depth of 1000 fathoms; and though it was made in the old method (with a heavy weight and large line), yet, as it was a good "up and down" sounding, the actual depth was probably not far short of the length of line run out. The weight, when drawn up, appeared to have sunk into the soft greenish mud which formed the bottom; for this mud still adhered not only to the weight but to several feet of the line; and imbedded in it were found specimens of a Tubicolar Annelid. A magnificent specimen of the "Medusa-head" Starfish, best known by its Lamarckian name *Euryale*, but more properly designated *Astrophyton*, was found clasping the line at so short a distance above the mud, that broken fragments of its arms were picked out from it, which were preserved by the officers as *mementos*. Hence it is obvious that this *Astrophyton* must have been brought up *from the bottom* on which it was living; and the case is therefore not only interesting as the first of its kind, but is of really greater value as proving the possibility of the existence at great depths of Animals by no means among the lowest in the scale of organization than some of the observations which have been subsequently adduced in support of this view.

The high authority which Edward Forbes had deservedly gained in this department of inquiry, caused his conclusion to be adopted by the Zoologists, Physical Geographers, and Geologists, both at home and abroad, with much less reserve than he would probably himself have wished; chiefly, as it would seem, because it appeared to afford a simple explanation of phenomena which had long perplexed Geologists and Palæontologists,—viz. the occurrence at various epochs of vast accumulations of sedimentary strata apparently altogether devoid of organic remains. But as his brother, Mr. David Forbes, has recently remarked with full justice, the

hypothesis of an *Azoic* or absolutely sterile zone, ranging from 300 fathoms downwards was brought forwards by him rather as a suggestion worthy of consideration, than as a dogma or established principle; indeed, in his latest work,* which his premature death prevented him from completing, he spoke of the confines of the lowest inhabited Zone as being still undetermined: and expressed the opinion that "it is in the exploration of this vast Deep-Sea region that the finest field for submarine discovery yet remains,"—words of which subsequent events have proved the philosophic prescience. It is not a little interesting that a few pages further on (Op. cit. p. 51), he quotes a letter from his friend, Harry Goodsir (who was a member of Sir John Franklin's ill-fated expedition), announcing "a capital haul" from a depth of 300 fathoms in Davis' Straits; which included Mollusca, Crustacea, Echinoderms, and Coral. He must have heard, too, of the results of the Dredgings carried on in Sir James Ross's Antarctic Expedition, at depths of from 270 to 400 fathoms, which yielded evidence of great abundance and variety of Animal life below what he had been led to regard as its limit. And it can scarcely be doubted that if his life had been prolonged, he would himself have endeavoured to obtain the means of carrying out the explorations to which, as just shown, he attached so great a value; and would have been induced by the love of truth which so eminently characterized him, to abandon a hypothesis which he would have found to be inconsistent with facts. Knowing Edward Forbes as I did, I can heartily endorse the assertion of Mr. David Forbes, that all who knew his gifted brother "will do his memory the justice of believing that, were he now alive, so far from regretting the necessity of withdrawing a suggestion which appeared to explain points in science now once more involved in obscurity, he would have been the first of the converts to the views now proved to be more correct, and the first to congratulate the members of the Deep-Sea Dredging Committee upon so successful and brilliant a termination of their labours." †

The only new facts in regard to the life of the Deep Sea that were brought to light previously to 1860, were those obtained by the use of improved forms of Sounding Apparatus; which, as explained in my former paper, not only enabled the depth of the Ocean-bed to be more precisely determined, but brought up samples of the material covering its bottom, the microscopic examination of which furnished results of most unexpected interest. It was first made

* "Natural History of the European Seas," p. 27.
† "Nature," Nov. 25, 1869, p. 101.

known by the late Professor Bailey (of West Point, United States), in 1855, that a large proportion of the bottom of the North Atlantic Ocean, at depths of from 1000 to 2000 fathoms, is covered by a mass of microscopic Foraminiferal shells (chiefly *Globigerinæ* and *Orbulinæ*), imbedded in a fine calcareous mud, strongly resembling chalk, which he considered to have been formed by their disintegration. He seems to have inclined, however, to the belief that these Foraminifera had not lived on the bottom on which they were found, but that they had either been transported thither by currents, or had lived nearer the surface of the sea, and had fallen to the bottom after death. On the other hand, Professor Ehrenberg, to whom specimens of these Soundings had been forwarded, expressed his conviction that the *Globigerinæ* had lived on the bottom from which they were brought up; his judgment being based on the condition of the organic substance contained in the cavities of their shells. Similar conclusions regarding the extensive diffusion of *Globigerinæ* over the deep-sea bottom of the North Atlantic, and the probability of their being alive on that bottom, were expressed by Professor Huxley as the result of his examination of the soundings taken by Lieutenant Dayman in 1857, between Ireland and Newfoundland, along the projected line of the Atlantic Cable. Of the whole mass of the fine muddy sediment of which these soundings consisted, he estimated that 85 per cent. consisted of *Globigerinæ*, 5 per cent. of other *Foraminifera*, and the remaining 10 per cent. partly of siliceous organisms (*Diatoms* and *Polycystina*), partly of mineral fragments and partly of very minute granular bodies, to which he was the first to draw attention, under the name of *Coccoliths*. Of these we shall have more to say hereafter.

These results were confirmed and extended by the observations of Dr. Wallich, made during the Sounding voyage of the "Bulldog," under Sir L. McClintock in 1860, which led him to the very decided conviction that the *Globigerinæ* have their home on the sea bottom, and not in intermediate or superficial waters. "They have never," he says, "been detected free-floating in any number in deep, or forming deposits in shallow waters; a considerable proportion of those met with in deep-sea deposits exhibit every appearance of vitality, and their maximum development is associated with the presence of the Gulf Stream." He also recognized the general prevalence of Professor Huxley's *Coccoliths*, and further showed that they are often disposed on the surface of spherical masses, to which he gave the name of *Coccospheres*. The subsequent recognition of these bodies by Mr. Sorby as abundant components of ordinary

chalk, increased the evidence of the close resemblance which had been previously indicated between the *Globigerina* mud at present in process of deposition and the ancient cretaceous formation.

A further addition of importance was made by the "Bulldog" Soundings to our knowledge of the Animal life of the Deep Sea. On one occasion the line brought up a cluster of *Ophiocomæ* (brittle-stars), attached to a portion of it, which had lain on the bottom at a depth of 1260 fathoms; and Dr. Wallich's conclusion that they had lived on this bottom, and had not been entangled by the line (as some Naturalists suggested) during its ascent through the intermediate waters, was fully justified in my opinion by a consideration of the circumstances under which they were obtained. For having kept *Ophiocomæ* in an aquarium for several weeks together, I know that they ordinarily live on the bottom, whilst I never saw them swim (as a *Comatula* does), and cannot believe them to be capable of doing so; whilst I also know it to be their habit to cluster round a rope lying on the ground they frequent—the first I ever saw alive having been obtained for me by the harbour-master of Plymouth, who sank a rope in a part of the Sound, on the bottom of which he knew them to abound, and drew it up again after some hours, swarming with *Ophiocomæ*. Further, it was found by Dr. Wallich that their stomachs contained *Globigerinæ*, so that unless these had been caught by the *Ophiocomæ* while both were swimming near the surface, which seems in the highest degree improbable, the Globigerina mud of the bottom must have been their feeding ground. Again, the "Bulldog" Sounding apparatus brought up in various localities, from depths ranging between 871 and 1913 fathoms, tubes of small marine worms, some of which were constructed of *Globigerina* shells cemented together, whilst others were made up of an admixture of sand and sponge-spicules. These materials, it is obvious, could not have been obtained anywhere but on the sea-bottom, so that the worms which used them must have had their habitation there. Lastly, a living *Serpula* and *Spirorbis* (marine worms forming shelly tubes), and a group of *Polyzoa* were brought up from a depth of 680 fathoms, and a couple of living *Amphipod Crustacea* from a depth of 445 fathoms.

The general bearings of these facts, together with those furnished by the earlier observations of Sir John Ross and others, were fully and ably discussed by Dr. Wallich in his "North Atlantic Sea Bed," and the most important of the conclusions which he drew from this discussion may be summarized as follows:—

1. The conditions prevailing at great depths, although differing

materially from those which prevail near the surface of the Ocean, are not incompatible with the maintenance of the life of animals, which are either originally adapted to live under them, or have become gradually acclimatized by a slow subsidence of the sea-bed.

2. The discovery of even a single species living normally at great depths, warrants the inference that the Deep Sea has its own special Fauna; and the number of different types of which examples have been obtained, justifies the conclusion that the Deep-Sea Fauna is both varied and abundant.

3. As the Deep Sea has its own special Fauna at the present time, it has always had it in past ages; and hence many fossiliferous strata hitherto regarded as having been deposited in comparatively shallow water, may have been deposited at great depths.

These conclusions, however, did not by any means command general assent; some of the data on which they were based having been called in question by very eminent authorities, whilst others who were ready to accept Dr. Wallich's *facts*, were unwilling to admit the *inferences* he drew from them as having more than a speculative value. It is clear that the great body of Naturalists, both at home and abroad, including those who recognized the diffusion of *Protozoic* life over the Deep-Sea bed, continued to regard the presence of higher animals at great depths as altogether exceptional, and that although obliged by the results of the dredgings carried on in the Arctic and Antarctic expeditions, to lower Edward Forbes's *zero* from *three* hundred to *four* or *five* hundred fathoms, they still believe that such a zero existed *somewhere*. Now that the absence of any such limit in regard to the higher forms of Animal life has been fully proved by subsequent researches, it is just that Dr. Wallich should receive the fullest credit for the sagacity which led him to the conclusions he adopted, and for the earnestness with which he advocated them. But it can scarcely be claimed for him that his researches were in themselves sufficient to establish his position; since the number of types of higher Animals which he brought up from great depths very little exceeded that which Captain Ross had obtained forty years before. It is specially noteworthy that up to the year 1861, not a single *Mollusk* had been obtained from greater depths than those which had been reached by the Dredge; and while this negative fact could not rightly be considered as conclusive evidence of the universal *absence* on the Deep-Sea bed of the most characteristic inhabitants of shallower waters, a Naturalist who had found them only in the depths of his own con-

sciousness, was scarcely in a position to demand a general assent to his belief in their *presence*.*

In the year 1861, however, two very important contributions were made to our knowledge of the Deep-Sea Fauna, both of which afforded positive evidence that Molluscan life is not limited to what we have now come to regard as the comparatively shallow depth of from 300 to 400 fathoms, whilst one of them not only gave the same proof in regard to the Stony Corals, but also afforded the first indication of the very curious relation (fully confirmed, as will be shown hereafter, by subsequent research) which the existing Deep-Sea Fauna bears to what had been previously regarded as the extinct Fauna of later Geological periods.

In the Swedish expedition to Spitzbergen in 1861, a compact mass of mud was brought up from 1400 fathoms by the "McClintock apparatus" (described at page 230 of my former paper), in which were imbedded a *Hydroid Polypary*, some *Tunicata* attached to it, a *bivalve Mussel*, and a *Crustacean of bright colours*. It was noted that the temperature of the interior of this mass was $32^{\circ}{\cdot}5$, that of the surface-water being $39^{\circ}{\cdot}2$.

It happened in the same year that the French Submarine Cable between Sardinia and Algiers was taken up for repairs, and that several living Mollusks and Polyparies were found attached to portions of it which had been submerged to a depth of from 2000 to 2800 *mètres*, or from 1093 to 1577 fathoms. These were carefully examined by M. Alphonse Milne-Edwards with very interesting results. One of the Mollusks was the *Ostrea cochlear*, a common Mediterranean shell, which has since been found at correspondingly great depths in the "Porcupine" dredgings off the West of Ireland, on the border of the Atlantic basin. Another was the small *Pecten opercularis*, also well known as a Mediterranean shell, which was specially remarkable for the brightness of its coloration, and with this was found the *Pecten testæ*, previously known as a rare species, inhabiting depths of from fifty to sixty fathoms. With these three Bivalves were associated two Univalves, ordinarily consi-

* The deficiency of evidence on this point was thus clearly stated at the time by M. Alphonse Milne-Edwards: "Lors même que l'existence des Vers, des Spongiares, des Foraminifères, et d'autres Animalcules Microscopiques dont je vieus de parler, serait bien démontrée dans les grandes profondeurs où leurs dépouilles ont été rencontrées, on n'en pourrait rien conclure touchant la présence de Mollusques ou de Coralliaires vivants dans les conditions analogues; et ce sont précisément ces animaux marins dont le mode de distribution à la surface du globe a la plus d'importance pour la solution des questions géologiques."—"Annalès des Sciences Naturelles, 4ième Sér., Zoologies" tom. xv. (1861), p. 152.

dered very rare—*Monodonta limbata* and *Fusus lamellosus;* and although these were not fixed to the cable like the Bivalves, yet the fresh condition of their soft parts clearly indicated that they were not drift shells, but that they had lived where they were found. The Polyparies, like the Bivalve Mollusks, were fixed to the cable, and were of peculiar interest. One of them could be identified with the *Caryophyllia arcuata* of the later Tertiary formations of Piedmont and Sicily; another *Caryophyllia,* not known as an existing species, was identified with a Pliocène fossil; and a third type, though belonging, like the others, to the *Turbinolian* family, was considered to be generically distinct from any Corals previously known, and was described under the name *Thalassiotrochus telegraphicus.* Besides these animals, there were found attached to the cable a small Polyzoary belonging to the genus *Salicornaria,* some Zoophytes of the *Gorgonia* type, and two *Serpulæ.*

These observations were of special interest in many points of view. There could be no doubt as to the depth from which the animals were brought up, since all of them, save the two Univalves, were actually fixed to the cable, which had lain along a bottom that had been carefully sounded; and though the Gasteropods were free to crawl upon its surface, they certainly could not have been swimming in mid-water, and have attached themselves to the cable as it came up. Again, whilst some of these animals were previously well known as occurring at smaller depths, others had been considered very rare, and one was previously unknown, so that it seems not unlikely that such find their most congenial habitation in abyssal waters. But the most significant fact of all was the discovery of animals still living at great depths in the Mediterranean basin, of which the remains are preserved in the Tertiary strata that bound it, but of whose continued existence no Naturalist had previously the least suspicion; and M. Alphonse Milne-Edwards was perfectly justified by this fact in the anticipation he expressed at the conclusion of his account of it—that his observations warrant the expectation that a more complete exploration of the depths of the sea would bring to our knowledge the continued existence of many species which have been hitherto considered as extinct, because they are only known in the fossil state.

The value of these observations was fully recognized by those among Geologists and Palæontologists who were gradually being led to the great doctrine of *Continuity,* as a substitute for that of successive creations and destructions of the Life of the Globe, which had dominated in the earlier stages of the Science. But nothing was done for several years to confirm or extend them.

The *Sounding-apparatus*, as shown in the former paper, can only be trusted to bring up a sample of the deposit covering the spot of the bottom on which it strikes; and the few star-fish or worms it may chance to entangle, can by no means be regarded as affording any adequate basis for judgment as to what *other* forms of life may exist on the Sea-bottom, or for any estimate of their relative abundance. It is only by the systematic use of the *Dredge* that such a basis can be obtained; and the working of this apparatus at great depths involves requirements that no private resources can command.

The Deep-Sea Dredge does not essentially differ from the instrument ordinarily used by Fishermen for collecting Oysters or Clams, and by Naturalists for collecting Marine Animals of all kinds. It may be likened to a carpet-bag, the iron frame of which is fixed in a half-open position, with edges directed obliquely outwards; and when this is trailed along the sea-bed by a rope attached to a pair of handles fixed by joints to the ends of the frame, the edge in contact with the ground scrapes the surface, and conveys into the bag of the dredge the animals that may be lying on it, together with stones, sand, or mud, separately or combined, according to the character of the bottom. The ship or boat from which the dredge is worked must have a certain amount of "way," so as to drag the dredge with the requisite force; but if the rate of the vessel's motion is too rapid, the dredge will pass over the ground without "holding" it; and if the momentum of the vessel be great (as is the case with even the smallest sea-going ship, at however slow a rate it may move), there is danger of the dredge-line breaking, whenever the dredge "anchors" or "fouls" by catching on a projecting rock, unless special precautions are taken to prevent this accident. One of the simplest of these precautions consists in the attachment of the dredge-line to only one of the handles of the dredge; the other being connected with it by a piece of cord or rope-yarn considerably inferior to the dredge-line in strength. If the dredge should "foul," the strain on the line will cause the rupture of the cord that holds together the handles; and one of them being thus set free, the dredge swings round the obstacle, and may be safely hauled in, though with the loss of its contents.

When Deep-Sea Dredging is carried on from a Steam-vessel, the piece of apparatus called an "accumulator" may be made of essential service. This simply consists of a number of vulcanized india-rubber springs resembling the A B C door-spring on a large scale, connected together at their extremities; and as every one of these springs, when drawn out to its full length, exerts a tension of

about 60 lbs., any tensile power that may be needed may be gained by the multiplication of them. The Accumulator being fixed to the ship at one end, the pulley through which the dredge-line passes is attached to the other; and any excessive strain put upon this is at once manifested by the extension of the springs, while the suddenness of the strain is eased off, so as to give time for relieving it by a backward motion of the paddles, which generally allows the dredge to lift itself over the obstacle.

For Deep-Sea exploration it is requisite that the Dredge should be of great strength and massiveness; and the power required to work it is very considerable. For not only must this be adequate to raise the dredge itself with its contents from any depth, but also to haul in a still greater length of the large and strong dredge-rope. Now the excess of the weight of this rope above that of the water which it displaces, forms a very considerable addition to the weight of the dredge and its contents; and to this has further to be added the enormous resistance produced by the friction of this length of rope in its passage through the water. In the 2435 fathoms dredging which was successfully carried through in the Second cruise of the "Porcupine" last year, a dredge was used, which, with the addition of 2 cwt. attached to the dredge-line, weighed about 500 lbs., this brought up 168 lbs. of Atlantic mud, in which many animals were imbedded; and the excess-weight of more than three miles of dredge-rope payed out was about 1375 lbs.; making a total of *nearly a ton,* in addition to the resistance produced by friction. And in another instance the dredge brought up from about one-third of the depth last-mentioned not less than *half a ton* of Atlantic mud; while the weight of the dredge with its appendages, and the excess-weight of the dredge-line, increased the whole to *above a ton,* besides the resistance caused by the friction of more than a mile of dredge-rope.

Thus Deep-Sea dredging is a very different operation from the working of the ordinary Collector's dredge in shallow water; and it can only be advantageously prosecuted from a vessel provided with a "donkey-engine" of adequate power and steadiness of action. A yacht with a crew of five or six men may work a moderate-sized dredge by manual power at the depth of from 200 to 300 fathoms; but a much larger crew is needed when the dredging is carried down another 100 fathoms; and the strain upon their powers is then so great that the operation cannot be often repeated. An efficient "donkey-engine," on the other hand, never becomes tired; and will go on heaving-in its heavy load,

hour after hour, with great uniformity.* In the first of the dredgings just referred to, the rate of delivery of the rope was about 10 fathoms per minute, or 600 fathoms per hour; and thus five hours were consumed in hauling-in the 3000 fathoms of dredge-line which it had been necessary to pay out,—more than two hours having been previously occupied in the sinking and dragging of the dredge. Thus even with the best appliances, such an operation is a very tedious one; and as it requires very favourable weather, as well as skilful management, it is not likely to be frequently repeated with success, save in an Expedition specially directed to this object. The most valuable results may probably be looked for between 600 and 1200 fathoms; and in a well-equipped vessel, with a trained crew, our experience proves that dredging may be systematically carried on at such depths without any hindrance except from weather.

It is to M. Sars, junr., the son of the late eminent Professor of Natural History at Christiania, that the credit should be assigned of having systematically worked the Dredge at depths which Edward Forbes had pronounced to be *azoic;* and of having not only proved that they are peopled by a varied and abundant Fauna, but that this Fauna is characterized by peculiarities of the highest interest,—many of the forms it presents being dissimilar to those met with in shallower waters, and some of them belonging to types which had been supposed to have been long since extinct. Holding the position of Inspector of Fisheries to the Swedish Government, M. Sars visited the Loffoden Islands in 1866; and carried on his explorations there at depths ranging between 200 and 450 fathoms. Within this range no fewer than 427 species were collected; the proportions respectively belonging to the principal groups being as follows:—68 Rhizopods, 5 Sponges, 22 Zoophytes, 36 Echinoderms, 57 Worms, 39 Molluscoids, 94 Mollusks, and 106 Crustacea. No fewer than 42 of these, including members of all the higher groups, were found at 450 fathoms.

The most interesting of all the new forms obtained by M. Sars, was a small *Crinoid,* differing in the most marked manner from any type previously known to exist at the present time, but clearly belonging to the *Apiocrinite* family which flourished in the Oolitic period,—the large *Pear-Encrinite* of the Bradford Clay being its most characteristic representative, while the far smaller *Bourgueticrinus* of

* Our experience of the unsatisfactory performance of the *single*-cylinder donkey-engine supplied to the "Lightning," in which our first Dredging-voyage was made, led us to press for a *double*-cylinder engine as essential to the success of the "Porcupine" Expedition of the following year; and this did its work most admirably.

the chalk seemed to be its latest. This discovery proved so suggestive, and gave such a powerful impetus to further research, that it marks an era in the history of the inquiry into the Life of the Deep Sea; and some account of the little animal which was the subject of it, as well of its relationships, may therefore be most appropriately introduced here.

The whole Order CRINOIDEA, or *Lily-stars,* is one of peculiar interest to the Palæontologist. Though among the most varied in form, and abundant in number of all the inhabitants of the ocean, through very long geological periods, these beautiful stalked starfish were, until recently, believed to be at present extremely limited in number, and restricted to a very few localities; so that the Zoologist considered himself fortunate who could secure a good specimen even at a high price. As was eloquently said of them by Edward Forbes,* "Their fossilized skeletons constitute great tracts of the dry land as it now appears; for miles and miles we may walk over the stony fragments of the Crinoidea; fragments which were once built up in animated forms, encased in living flesh, and obeying the will of creatures among the loveliest inhabitants of the ocean. Even in their present disjointed and petrified state, they excite the admiration, not only of the Naturalist, but of the common gazer; and the name of Stone-lily popularly applied to them, indicates a popular appreciation of their beauty. To the philosopher they have long been the subjects of contemplation as well as of admiration. In him they raise up a vision of an early world, the potentates of which were not men but animals, of seas on whose tranquil surfaces myriads of convoluted Nautili sported, and in whose depths millions of Lily-stars waved wilfully on their slender stems. Now the Lily-stars and the Nautili are almost gone; a few lovely stragglers of those once abounding tribes remain to evidence the wondrous forms and structures of their comrades. Other beings, not less wonderful, and scarcely less graceful, have replaced them: while the seas in which they flourished have become lands, whereon man, in his columned cathedrals, and mazy palaces, emulates the beauty and symmetry of their fluted stems and chambered shells."

The only existing type of this Order which was known to Naturalists half a century ago, belong to the genus *Pentacrinus* (so named on account of the pentagonal form of its stem), which flourished during the Liassic period; its remains being abundantly preserved in great slabs of lias which the quarries at Lyme Regis have furnished to museums in every part of the world; whilst its recent representa-

* "British Starfishes," p. 2.

tives were known only as inhabiting West Indian seas. But in the year 1823, Mr. J. V. Thompson, a retired Army-surgeon, discovered in the Bay of Cork, a beautiful little Crinoid, measuring about three-fourths of an inch in height, and when expanded about half an inch in diameter. This discovery excited great interest both at home and abroad; for it was the first animal of the Crinoid type which had been met with in European seas, and the first recent Encrinite which had ever been examined by a competent observer, in a living state. The further study of this interesting creature led its discoverers to announce in 1866, that it is the young or immature form of the *Comatula*, or Feather-star, an Echinoderm; which though unattached and a free swimmer, had been previously shown to possess a far closer relationship to the Crinoids than it has to any other Star-fish. The *Comatula* thenceforth took rank as an actual member of the Crinoid order, and peculiar only in dropping off at a certain phase of its existence from the stem on which it was at first developed, and leading from that time forth a life of freedom.

For several years past, the study of the recent types of the Crinoids had been a special object of pursuit on the part of Prof. Wyville Thomson and myself, with a view to the elucidation of the structure and homologies of that large and varied series of fossil forms, by which the Crinoids of past ages are now brought to the knowledge of Palæontologists. It was, therefore, with peculiar interest that we heard of M. Sars's discovery; and that we were enabled to ascertain beyond all doubt, by the examination of specimens kindly supplied to us, that this new Crinoid was not, as some had suggested, the larval form of a *Comatula* (its skeleton differing as much from that of any such larva, as the shrunken and solidified skull of an aged person differs from the loosely-united brain-case of an infant), but a mature type, distinctly referable to the *Apiocrinite* family, which had been supposed to have died out long since. The generic designation *Rhizocrinus* has been given to this type, on account of the curious root-like extensions which proceed from the lower part of its stem (see illustration), and which serve for its attachment to the Zoophytes, etc., on which it is usually found. The Crinoidal larva of *Comatula*

RHIZOCRINUS LOFOTENSIS.

attaches itself by a simple disk, to which the lowest joint of the stem is jointed. Of the base of the recent West Indian *Pentacrinus* we have no knowledge; all the specimens hitherto obtained having been detached by the breaking of the stem. But the bases of the great fossil Crinoids, and especially of the Apiocrinites, are often well preserved; and are always truly rootlike. Usually, however, the stem rises from the point of juncture of the roots, just as in an ordinary tree; but in *Rhizocrinus* the roots often come off from many successive segments of the stem, just as the roots of *Pandanus* (Screw-pine) and some other trees are given off from the trunk far above the ground. The thread-like stem of *Rhizocrinus*, which is usually in a full-grown specimen from two to three inches long, is made up, like that of the Crinoids generally, of a number of segments jointed together; and these are for the most part nearly cylindrical in form, becoming gradually smaller from the base to the summit of the stem, which thus tapers gradually from below upwards. But very considerable varieties and irregularities sometimes present themselves. The segments are often contracted in the middle of their length, so as to have the shape of a dice-box, and this contraction sometimes proceeds so far as to give the segment the form of an hour-glass; and the stem, instead of gradually tapering, sometimes suddenly diminishes in diameter, as if it had been broken off, and had grown again from the point of fracture. The lower part of the calyx, which is borne at the summit of the stem, is like what that of a miniature Pear-Encrinite would be, if the flattened discoidal plates, piled one upon another, of which it is made up, were all soldered together; and the hollow in its upper part, which includes the visceral apparatus, is exceedingly small. This hollow is enclosed, as in *Pentacrinus*, by the plates forming the bases of the *rays* which give the creature its resemblance to a Star-fish; and here again we find a very curious departure from the typical character. For, whilst the number of primary rays in the Crinoids generally is almost invariably *five*, it varies in *Rhizocrinus* between *four* and *seven*. In the Crinoids generally each ray bifurcates at the edge of the calyx into two *arms;* and this bifurcation is often again repeated, more than once in many instances, so that the number of arms becomes extremely multiplied, as we see in the magnificent *Pentacrinus briareus* of the Lias. Here, on the other hand, there is no bifurcation, so that the number of arms is the same as that of the rays; in fact, the arm is a simple continuation of the ray, except that its diameter is suddenly reduced at the point where the bifurcation would take place. Now it is not a little curious that among the monstrosities which I have observed

and described in *Comatula*, there is one precisely of this character—a single arm taking the place of the pair into which the ray normally divides.

Taking all these peculiarities into account, I entirely agree with Professor Sars in the conclusion that his *Rhizocrinus* is a dwarfed and deformed representative of the Apiocrinite type; looking, as Professor Wyville Thomson has well phrased it, "like a *Bourgueticrinus* which had been going to the bad for a million of ages, somehow getting worsted in the 'struggle for life.'" Carrying back the same idea, we might surmise that the *Bourgueticrinus* itself may have been the lineal descendant of one of the great Pear-Encrinites of the Oolitic period, which, during the millions of ages that elapsed before the chalk formation began to be deposited, was undergoing the like degeneration. The process would thus resemble the decay of some old family which once held its head high in wealth and power, but which has gradually become "reduced in circumstances;" its poverty-stricken representatives having first come to live as tenants or labourers on the estate once owned by their forefathers, and having finally been reduced to a condition of abject beggary.

It is a matter of no small interest that the *Rhizocrinus*, though first discovered by Sars near the Loffoden Islands (which lie off the north-western part of the Norwegian coast), has since been obtained in the "Lightning" and "Porcupine" dredgings at various points, and at very considerable depths along the eastern border of the Atlantic basin from the Faroe Islands to the Bay of Biscay, and that Count Pourtales, who has been engaged in the United States Coast Survey of the Gulf Stream, met with it off the reefs of Florida. And since, as will presently appear, another Crinoid of the Apiocrinite type can live at the depth of nearly three miles—the greatest yet explored by the dredge—it is probable that the little *Rhizocrinus* is generally diffused over the North Atlantic sea-bed, save where an extreme depression of its temperature is produced by Arctic currents.

It was the remarkable success of M. Sars's researches, and the interest excited by them, which (as already narrated, p. 226) led Professor Wyville Thomson and myself in 1868, to propose to the President and Council of the Royal Society that our own Government should be requested to place means at our disposal for similar explorations, and the Admiralty, on the recommendation of that body, has provided us for two consecutive seasons with an equipment which has enabled us to carry on dredging operations at depths which would have been previously considered altogether beyond their reach, and has now liberally extended this aid to a third year. But before giving an

HOLTENIA CARPENTERI.

account of the researches which we have thus been enabled to prosecute into the Life of the Deep Sea, it is but fair to state that we had been anticipated in this inquiry by the United States Coast Survey; which, being engaged in the careful examination of the part of the Gulf of Mexico that forms the outlet of the Gulf Stream, directed Count Pourtales, who had previously distinguished himself in the practical study of Marine Zoology, to carry on Deep-Sea dredging in connection with the work of the survey. This he commenced in the spring of 1867, and though the work of the expedition was much interrupted by the breaking out of yellow fever on board, so that only a few casts of the dredge were obtained, yet these were sufficient to satisfy Count Pourtales (who seems at that time to have been unacquainted with Sars's researches) that animal life exists at a depth of 270 fathoms in as great a diversity and as great an abundance as in shallow waters. The promising characters of these results led Professor Peirce, the Superintendent of the United States Coast Survey, to decide upon sending out Count Pourtales in the following year with a better equipment; and in the spring of 1868, at the very time when our own expedition was first proposed, he was actively carrying on the work in which we were anxious to engage. As before, the explorations were prosecuted within the outlet of the Gulf Stream, between the Florida Reef, the Bahama Bank, and the Coast of Cuba; and the depths attained were from 100 to 517 fathoms. It was between 250 and 350 fathoms that the greatest abundance of animal life prevailed. Many new species were procured, some of them in extraordinary numbers, but there were not many new genera, except among Echinoderms. Among the most interesting of the new types was a living Crinoid, referred by Pourtales to the species of *Bourgueticrinus*, which had been described by D'Orbigny as occurring in a fragmentary state in the recent breccia of Guadaloupe, wherein is imbedded the so-called "fossil human skeleton," preserved in the British Museum. This was a remarkable verification of D'Orbigny's surmise that the species might probably be found living in the West Indian seas; and still more remarkable was the proof subsequently obtained of its identity with the Loffoden *Rhizocrinus* of Sars. Between 350 and 517 fathoms (the last being the greatest depth to which dredging had then been carried), the bottom was found to be usually covered with *Globigerina* mud, and with this were brought up various examples of higher types, though the Fauna was much less varied as well as smaller in size, than that of the range between 250 and 350 fathoms. It was specially noted that colour was by no means deficient among deep-sea animals, and that they

have generally well-developed eyes, larger if anything than those of their congeners of shallow waters. At the conclusion of Count Pourtales' Report of the Deep Sea Explorations of 1867 and 1868, Professor Agassiz drew attention to the indications of identity between several of the types of Echinoderms and Corals discovered in the deeper parts of the West Indian seas and those of the Northern coasts of Europe, and this he attributed to the transporting agency of the Gulf Stream. The proofs of such identity have been greatly multiplied by the researches of the last two years, but so long as the *temperature* of the sea-bottom, from which the various West Indian species were brought up, is not recorded, it would be premature to form any opinion as to the causes of this peculiar distribution, which may possibly prove to be the very opposite, in some instances at least, of Professor Agassiz's conjecture. The immense importance of temperature observations in connection with Deep-sea dredging, will become apparent in the summary I shall now give of the general results of the Deep-Sea dredgings carried on during the "Lightning" expedition of 1868, and the "Porcupine" expedition of 1869.

The lateness of the date at which the "Lightning" expedition started, and the further limitation of its opportunities for Deep-sea exploration, occasioned by unfavourable weather, reduced the number of days available for dredging on a bottom exceeding 500 fathoms' depth to *five*; but the results of the work done in these proved of the highest interest, and prepared the way for a more effectual prosecution of the inquiry. Our first deep dredgings were carried on the *Cold Area,* over which, as described in the previous paper, a stream of Arctic waters reduces the temperature of the sea-bed to about 30°. The bottom here consisted of sand and stones, and there was an almost entire absence of *Foraminifera.* This fact, which our subsequent researches fully confirmed, is one of fundamental importance with reference to the question whether the *Globigerinæ* live and multiply on the bottom, or live near the surface and sink to the bottom after death. For since, as will be recollected, the temperature of the upper stratum of waters is the same in the cold area as in the warm, there is no reason why, if the latter were the case, the *Globigerinæ* should not be found as abundantly on the *cold* sea-bed as they are on the *warm.* Of the Foraminifera which did present themselves, the most remarkable belonged to the *Arenaceous* type, in which the Calcareous shells of the *Porcellanous* and *Vitreous* series are replaced by "tests" composed of sand-grains cemented together, frequently with the most wonderful symmetry and perfection of fitting. The Fauna, though scanty, was by no means of a low order—all the more

elevated types of marine animal life—*Mollusca, Crustacea, Worms,* and *Echinoderms,* being represented in it. Several of them were most characteristic members of the Boreal Fauna—among these was the rare Norwegian star-fish *Brisinga,* which is remarkable for its close alliance to the fossil genus *Protaster.*

Even this first imperfect attempt served to prove that a depth exceeding 500 fathoms with a temperature below 32°, is not incompatible with the existence of animal life in considerable variety; and that so far from there being a predominance of low forms, the character of the Fauna is as high as that of the Northern shores from which it seems to be derived.

The more complete exploration which we were enabled to make of this Cold area, however, in the following year, with the further advantage of an improved method of collection, devised by our Commander, produced an unexpected modification in our ideas as to the comparative barrenness of its Sea-bed; for they proved it to be one of remarkable richness in certain types of animal life, and these by no means the lowest in the scale. Captain Calver having noticed that animals frequently came up attached to the part of the dredge-rope that had lain on the ground, or to the net of the dredge itself, justly reasoned that if the Sea-bottom were *swept* with hempen brushes, they would probably bring up many creatures that might escape the *scraping* of the dredge. These brushes were made of bundles of rope-yarn teazed out into their separate threads, and tied together at the top, so as closely to resemble the ordinary "swabs" used on board ship. An iron rod was attached to the bottom of the dredge, and carried out about two feet on either side of it; and it was to these projecting portions (resembling the studdingsail-booms extended from a yard-arm) that the "hempen tangles" were attached by Captain Calver, who rightly judged that if they were attached to the bottom of the dredge itself, they would only bring up what the dredge had passed over and crushed. Though the use of these "tangles" often added much to our "hauls" on the softer ground, yet it was on the hard bottom of the Cold area that their value became especially apparent, the "tangles" often coming up laden with the richest spoils of the Ocean-bed, when the dredge was nearly empty. Hence it is plain that no exploration of the Sea-bed can henceforth be considered complete, in which Capt. Calver's "hempen tangles" are not used in combination with the dredge; and that no inferences regarding either the absence or the comparative scantiness of Animal life on any particular bottom can be fairly drawn from the negative evidence afforded by the failure of the

dredge to collect samples of the forms that may be profusely spread over it.

The most marked feature in the Fauna of the Cold area is undoubtedly its extraordinary richness in *Echinoderms;* the prevalent types being of a decidedly Boreal and even Arctic character. During the course of our exploration we met with nearly all the members of this group which have been described by Scandinavian Naturalists as dwelling near the coast and in the fiords of Norway, and were particularly struck with the abundance of the beautiful *Antedon* (*Comatula*) *Eschrichtii,* which has hitherto been obtained only from the neighbourhood of Iceland and Greenland. On the other hand, such of the characteristically Southern forms as here presented themselves were so reduced in size, that they might almost be accounted specifically distinct, if it were not for their exact conformity in general structure; the common *Solaster papposa,* for example, being dwarfed from *six* inches in diameter to *two,* and having never more than ten rays; and the *Asterocanthion violaceus* and *Cribella oculata* being reduced in like proportion. One striking feature of the group, however, showed no modification. The *coloration* of these animals, though brought up from a depth of 500 or 600 fathoms, was as rich and beautiful as that of their littoral representatives. Their orange, violet, and scarlet blended admirably with the pale-green of the large Sponge-stem to be presently mentioned, when grouped together in a basin of water; and we were led to wonder, on the one hand, how such vivid hues could be produced in the absence of light, and, on the other, what purpose they can serve in the economy of animals which live on a bottom entirely unillumined by solar rays, and only exhibit them when brought within reach of these. Whilst our explorations in the Cold area thus added to the British Fauna a large number of types of *Echinoderms* which had been previously supposed to lie altogether beyond its range, they also brought up several forms which are altogether new to science, some of them of very considerable interest. Thus, in the Shetland channel we procured from a depth of 640 fathoms a full-sized specimen of a remarkable Clypeastroid form, of which young examples had been obtained in the first cruise. This we believed to be quite new; but soon after our return we learned that it had been obtained some months previously by Count Pourtales in his Gulf Stream dredgings, from a depth of 349 fathoms, and had been described by Mr. Alex. Agassiz, under the generic name *Pourtalesia.* He regards it as a living representative of the *Infulasters* of the Cretaceous period; resembling it in its extraordinarily prolonged form, which makes it more resemble a

Holothurian than a Sea-urchin, its mouth being at one extremity and its anus at the other. The interest attaching to the discovery of this curious type in so distant a locality, and under conditions apparently so different,* has fully compensated us for not having been the first to meet with it; more especially as we are able to give the generic name *Calveria,* which we had devised as a compliment to our excellent Commander, to another singular Star-fish which we believe to be new to science.

Of the *Crustacea* of the Cold area, many are most distinctly referable to the Fauna of Spitzbergen, whilst others are characteristically Norwegian. We were struck with finding attached to the "tangles," on nearly every occasion, numerous specimens of very large *Pycnogonids,* measuring, when their limbs were extended, as much as four or five inches across. The comparatively small forms of these animals that are common on our own shores, are commonly found imbedded in the gelatinous layer that envelopes the surfaces of *Algæ,* and the suctorial character of their mouths, taken in connection with the feebleness of their locomotive powers, seems to indicate that they are nourished by the ingestion of this material. Hence it is probable that their gigantic representatives living on the Sea-bottom make the same use of the sarcodic substance of the *Sponges* and *Rhizopods* which they there meet with.†

The *Mollusca,* which in other cruises usually constituted the principal results of the dredgings, were here quite subordinate, as regards both number and variety, to the groups already alluded to; and the difference between the Molluscan Fauna of the Cold and that of the Warm, was not by any means so great as was shown in other groups. One of the most interesting types which we met with was a Brachiopod found living, at Station 65 in the Shetland channel, at a depth of 345 fathoms, and a bottom-temperature of 30°, the—*Terebratula septata* of Philippi, = *T. septigera* of Lovèn. A variety of this, from the Pliocene beds of Messina, has been described and figured by Prof. Seguenza under the name of *Terebratella Peloritana,* and this variety is clearly the same as the *Waldheimia Floridana,* found in the Gulf of Mexico by Pourtales, which our own numerous specimens so considerably exceed in size as to show that

* It is much to be regretted that no information has yet been made public as to the temperature of the deeper parts of the Gulf Stream before its exit from the Gulf of Mexico. It is quite possible that it may prove to be comparatively low.

† It seems worth while here calling to mind that a *Pycnogonid* of even yet more gigantic dimensions was among the specimens obtained by what was at that time considered very deep dredging in Sir James Ross's Antarctic Expedition.

its most congenial home is in frigid water. A single specimen was found of another remarkable Brachiopod, the *Platydia anomioides* of Scacchi (= *Morrisia* of Davidson), hitherto supposed to be restricted, as a recent shell, to the Mediterranean, though the same, or a very similar species, is a characteristic and widely diffused Cretaceous type. Since in this case, also, the size of our specimen greatly exceeds the Mediterranean examples of the species (being nearly double), the presumption is strong that its original home is in the Boreal, perhaps even in the Arctic region.

Many beautiful *Stony Corals* were found at depths of from 500 to 600 fathoms in the Cold area, which presented every appearance of luxuriant growth. They have been carefully examined by Dr. M. Duncan,* who has been able to identify several of them with Corals dredged by M. Pourtales, in the Gulf Stream, and also with fossil forms preserved in the Italian and Sicilian Tertiaries. It is not a little curious that, as in the case of the Brachiopods just noticed, several of the Corals found in our Cold area were so much more fully developed than their representatives in warmer regions, that the former would seem to be their most congenial *habitat.* None of these Deep-sea Corals belong to the genera that furnish the reef-builders; so that the important doctrine of "Areas of Subsidence, and Areas of Elevation," founded by Mr. Darwin upon observations which indicate that the growth of Coral Reefs does not take place at a greater depth than 20 fathoms, remains unaffected.

The *Sponges* of the Cold area were proved by the "Porcupine" sweepings to rival the Echinoderms in variety and abundance; although our "Lightning" *dredgings* had scarcely brought up any from that bottom. Magnificent specimens were obtained of most of the species hitherto known only as inhabitants of much shallower water in the neighbourhood of Shetland; but the most peculiar and novel type of the group was one which we found universally diffused over the sea-bed, of which it seems to cover hundreds of square miles: although the "Lightning's" dredgings had only afforded a few fragments too minute and imperfect for their nature to be determined, this sponge is distinguished by the possession of a firm branching axis, of a pale sea-green colour, rising from a spreading root to a height of probably 18 inches or more, and extending itself like a shrub or a branching *Gorgonia.* The axis is clothed with the soft pale-yellow sarcodic substance of the Sponge; and both axis and Sponge-substance are crowded with siliceous

* On the *Madreporaria*, dredged up in the Expedition of H.M.S. "Porcupine," in the "Proceedings of the Royal Society," for March 24th, 1870.

spicules, resembling those of *Esperia*, a well-known Mediterranean and Adriatic type. This great abundance of *Sponges* in the Cold area seems to have a peculiar physiological significance, especially when taken in connection with the yet greater abundance of *Globigerinæ* and other *Foraminifera* upon the warmer bottom. Notwithstanding the wide difference between these two groups in the form and structure of their hard skeletons, every Biologist recognizes their close affinity; and we believe them to agree in this most important particular,—that the sarcodic substance of which the entire animal body is composed in both groups, is capable of imbibing into itself the nutrient material which has been shown to be diffused throughout the sea-water (p. 248); just as they derive from the same source the Carbonate of Lime or the Silex which forms the mineral basis of their skeletons. Once this diffused Organic matter has been concentrated and converted into sarcode, whether by *Globigerinæ* or by *Sponges*, the alimentation of all the higher members of the Deep-Sea Fauna becomes readily intelligible,—a rich feeding-ground being provided for them, in the Cold area by *Sponges*, and in the Warm by *Globigerinæ*.

It was after several days of interruption by foul weather, that, on our return southwards towards Stornoway in the "Lightning" cruise of 1868, availing ourselves of a lull that enabled us to resume our work, we put down our Dredge at Station XII. (see Map), where a previous sounding had given a depth of 530 fathoms and a temperature of 47°·3, which, corrected for pressure, would be about 45°. The results of this one dredging proved amply sufficient compensation for all the discomforts we had undergone from bad weather, a leaky ship, and what we feared might be deemed the inadequate return for the cost of the Expedition. The bottom consisted of a bluish white tenacious mud, consisting of *Globigerina*-deposit, mingled with fine sand, and having a viscidity that seemed attributable to the diffusion through it of Animal protoplasm. Our subsequent explorations fully accounted for this peculiar combination; for this Station, though lying within the Warm area, was so near the border of the Cold, that the Sand-drift of the latter was mingled with the Calcareous mud of the former,—just as is often observable in particular beds of the Chalk-formation. Imbedded in this mud there came up an extraordinary collection of *Siliceous Sponges* of new and most remarkable forms. Of one of these, to which we gave the generic name *Holtenia*, in compliment to our excellent friend the Governor of the Faroe Islands, a more particular account will be presently given. In company with it were living specimens of the *Hyalonema Sieboldii*, or

Japanese Flint rope, which has been the subject of so much controversy. The careful examination of these specimens since made by Professor Wyville Thomson, of which he will ere long publish the results, leaves no doubt whatever that the "rope" and the Sponge with which it is connected constitute one organism, whilst the incrusting Polype is parasitic, as was maintained long since by Professor Max Schulze, and subsequently by Professor Thomson himself (Intellectual Observer, vol. xi., p. 81). The *Foraminifera* here obtained were also of great interest, including many new and singular forms of the Arenaceous type, associated with large and beautiful *Cristellarians* of varied shape, and *Miliolines* of gigantic size. With these lower forms our dredge brought up a very rich haul of *Zoophytes, Echinoderms, Mollusks,* and *Crustacea;* including, to our great delight, two specimens of Sars's *Rhizocrinus.* We thus obtained positive evidence of the existence at a depth for the first time explored by the dredge, not of a degraded or starved-out residuum of Animal life, but of a rich and varied Fauna. This Fauna, though essentially British in its general character, included several types previously found only near the coast of Norway; while the large *Cristellaræ* and *Miliolines* and the *Siliceous Sponges* seemed rather to belong to a warmer temperate region. A subsequent dredging at Station XVI., nearly 300 miles to the North-west of the preceding, brought up from a depth of 650 fathoms, about 2½ cwt. of *Globigerina*-mud of peculiar viscidity, and everywhere traversed by long siliceous spicules, which subsequent examination proved to be the root-fibres of sponges. No large specimens came up in the dredge on this occasion; but a careful sifting of about half the entire mass of mud gave a number of small *Ophiocomæ, Polyzoa, Crustacea,* and a considerable variety of *Annelids,* many of them forming tubes by cementing *Globigerinæ* or Sand-grains in a most regular and beautiful manner. A new type of Zoophyte allied to *Pennatula* lay imbedded in the mud; and there can be little doubt that it had stood implanted in the soft bottom, like the *Pennatulæ* of shallow waters, whose occasional appearance at the surface is probably the result of accident.

The subsequent more careful examination of the Warm area which we were enabled to make in the latter part of the "Porcupine" expedition of 1869, fully confirmed the results of our first tentative exploration of it, and added many new and remarkable forms to those which we had been fortunate enough to obtain in our "Lightning" dredging. It was the *Holtenia*-ground that again proved most prolific, and our dredge with its tangles came up from it loaded with

such a collection of the "treasures of the deep," as may safely be asserted to have never been brought to the surface on any one occasion,—almost every specimen being such as would be accounted an important acquisition to museums already most complete. *Holtenias, Hyalonemas,* and other Siliceous sponges came up almost by the bucketful, the dredge and the hempen tangles being here alike productive. The *Echinoderms* were also very numerous, and many of them very large; and they presented a curious admixture of Southern and Norwegian forms, whilst nearly all of them were new to the British Fauna. On two occasions a most singular Echinidan was met with, which, like a church described by Thackeray in "Our Street," was at the same time "bran-new and intensely old." This looked externally like a sea-egg flattened out by pressure; it was about five inches in diameter, and of a brilliant crimson hue. Its test being composed of plates separated by membrane instead of being united by suture, was quite flexible, so as to resemble an armour of chain-mail rather than the inflexible cuirass with which the ordinary *Echinida* are invested. The nearest approximation to this singular type known to be presented by existing forms, is found in the *Diadema* family; but its relationship seems much closer to the very singular fossil from the White Chalk, described by the late Dr. S. P. Woodward under the name of *Echinothuriafloris.*

The most sanguine anticipations of the valuable results to be derived from the exploration of the Deep Sea would thus have been much more than realized by the exploration which we carried on at depths (which we have now come to consider quite *moderate*) between 500 and 700 fathoms. For not only did this exploration reveal the existence of numerous forms of animal life which were altogether new to science, and greatly extend our knowledge alike of the Geographical and the Bathymetrical range of others with which naturalists were already acquainted, but it also proved eminently suggestive in regard to the intimate relationships which it manifested between various existing inhabitants of the Deep Sea, and types characteristic of the Cretaceous and Tertiary periods which had been accounted long since extinct. As among these relationships there is none more interesting than that which our beautiful *Holtenia* (Plate I.) bears to the curious fossils of the White Chalk, known as *Ventriculites,* this type may be appropriately selected for more particular description.

The large importation that has recently been made of specimens of the beautiful *Euplectella* of the Philippine Islands, has made almost every student of Natural History familiar with the existence of a type of sponges, in which the *keratose* or horny framework (usually more

or less beset with siliceous or calcareous spicules) that forms the support of the living sarcode in the ordinary representatives of the class *Porifera,* is replaced by a complete *siliceous* skeleton. To this type, which has been ranked as a distinct order by Professor Wyville Thomson, under the designation *Porifera vitrea,* or vitreous sponges, several sponges are to be referred, that differ greatly in form, and are widely remote in geographical distribution; among them the large mushroom-shaped *Dictyocalyx* of Barbadoes, the *Hyalonema* or Japanese Flint-rope, the *Aphrocallistes* of the coast of Portugal, and several others. In some of these, as *Euplectella,* the principal spicules of the skeleton are, so to speak, soldered together to such an extent as to be with difficulty separated; the framework they form being thus very firm and complete, even when all its animal matters has been removed by boiling in nitric acid. But in others, as *Holtenia,* the spicules are less intimately united, and may for the most part be detached from each other by the destruction of the animal matter that connects them in the living fabric; and thus a gradational affinity is shown between the typical vitreous sponges and those in which siliceous spicules are worked into a keratose framework. An extraordinary variety presents itself in the forms of the spicules entering into the skeleton of *Holtenia;* and many of these forms have been supposed to be characteristic of diverse types of the sponges. See Plate II., Figs. 4—13 and 15.

Nothing could *look* more unpromising than did our *Holtenias,* when they came up penetrated throughout with the sandy mud, in the midst of which they lay imbedded, but the *touch* immediately revealed their character, and although deficient in the elegance of form by which the "Venus' Flower-basket" is pre-eminently distinguished, they proved scarcely inferior to it in the beauty of their siliceous framework, as exhibited in specimens from which the mud has been completely washed out, and the animal matter got rid of by decay. (Plate I. and Plate II., Figs. 2, 3, etc.) The body of this sponge is as large as a moderate-sized turnip; the central part of it is (so to speak) scooped out from above so as to form a pit, the mouth of which is surrounded by a collar of radiating spicules, tapering to fine points; whilst from its lower part there proceeds a sort of bushy beard composed of elongated cylindrical spicules, which extend far into the subjacent mud.

The *Ventriculites* of the chalk form a group which has greatly perplexed Palæontologists; partly, as it would now appear, on account of the metamorphic action which their fossil skeletons have undergone. "They have usually the form of graceful vases, tubes,

or funnels, variously ridged or grooved, or otherwise ornamented on the surface; frequently expanded above into a cup-like lip, and continued below into a bundle of fibrous roots. The minute structure of these bodies shows an extremely delicate tracery of fine tubes, sometimes empty, sometimes filled with loose calcareous matter, dyed with peroxide of iron." The late Mr. Toulmin Smith, who made a careful study of this group several years ago, came to the conclusion that their peculiarities of structure indicated their affinity to be rather with *Polyzoa* than with *Sponges;* and Dr. Bowerbank, who upheld their spongeous character, was unable to point to any recent sponge as presenting any close relationship to them. Professor Wyville Thomson, however, after a careful comparison of these *Ventriculites* with *Vitreous Sponges,* since discovered, has satisfied himself that they belong to that group; and accounts for the disappearance of the silex of their skeletons by a process of chemical solution, which has carried it away to help to form the solid flints, leaving their moulds only in the chalk. So far from being extinct, he believes that the group represented by the Ventriculites attains a much higher development at the present time than it did in the Cretaceous epoch; having apparently been gaining ground, while the Pear-Encrinites have been losing it.

The "Porcupine" dredgings of 1869, however, did much more than add to these *spolia opima* of depths previously unexplored, which we had been fortunate enough to obtain in the tentative "Lightning" expedition of the previous year. For by means of the excellent equipments provided by the Admiralty, and the skilful management of our excellent Commander, the dredge was worked on the Atlantic slope to the west-north-west of Ireland at depths progressively increased to 800, 1200, and 1500 fathoms, with results so satisfactory as to encourage the expectation that still greater depths might be explored with equal success. The greatest known depth within easy reach of a harbour having been found to be at the northern part of the Bay of Biscay, about 250 miles to the west of Ushant, the course of the "Porcupine" was directed thither; and my colleague, Professor Wyville Thomson (who had the scientific charge of that cruise), had the satisfaction of seeing the dredge come up from a depth of 2435 fathoms, or nearly *three miles,* loaded with about 1½ cwt. of *Globigerina*-mud (masses of which, when dried, have exactly the appearance and texture of ordinary chalk), imbedded wherein were representatives of the higher as well as the lower types of Marine Invertebrata, including a new Crinoid, belonging, like *Rhizocrinus,* to the Apiocrinite type, but generically different from it.

This most important result may be regarded as unequivocally proving that there is *no limit to the depth at which Animal life can exist in the Ocean;* for as the deepest reliable sounding has not anywhere given a greater depth than 3000 fathoms, there can be no condition save *pressure* which is necessarily altered. It has been shown (p. 248) that the Nutrition of Deep-Sea Animals is primarily dependent upon the organic matter diffused through the whole mass of Oceanic water; they can support themselves, therefore, as well at 3000 fathoms as at 2435. Their Respiration, again, is provided for by the diffusibility of the gases in solution: oxygen being exchanged for the carbonic acid generated by the Animal life of the bottom, however deep it may be, and the converse exchange taking place at the surface. As far as we know at present, no appreciable amount of light could penetrate to 1000 fathoms, and no greater depth, therefore, can be more completely removed from its influence; and as regards Temperature, when once a depth of 2000 fathoms has been reached, a further descent seems to make very little difference. Now the Pressure on the bodies of Animals at 2400 fathoms is about *three tons on the square inch,* while at 3200 fathoms it would be *four tons;* but the condition which makes the former bearable is by no means limited to a particular amount, and applies equally to that which Animals would have to sustain at *any* depth. That condition is the *equality in the pressure of fluids in all directions;* so that however delicate the conformation of an Animal composed of solid and liquid molecules, its *shape* will not be in the least affected (its *size* being only reduced in a measure that may be practically disregarded), nor will its *movements,* whether general or molecular, be in any way interfered with. Those to whom this statement may appear suprising, should call to mind the fact that the Atmospheric pressure upon the body of an ordinary-sized man exceeds *fifteen tons;* whilst a rise or fall of the barometer to the extent of an inch marks a difference of *half a ton* in that amount.

When we reflect that "we live and move and have our being," utterly unconscious of the enormous load we are bearing, and that we do not feel the laying-on or the removal of half a ton (or even more) as a variation in its pressure, we can more readily conceive how creatures destitute of air-cavities can sustain a pressure of even three or four tons upon the square inch, without its interfering in any way with their welfare or enjoyment.

The length to which this paper has extended renders it necessary to postpone to some future occasion a notice of some of the Geological bearings of recent Deep-Sea Explorations.

TABLE TO ACCOMPANY THE COLOURED MAP, OPPOSITE P. 225.

"PORCUPINE" SOUNDINGS.

Station, No.	North Latitude.	West Longitude.	Depth, Fathoms.	Surface Temperature, Fahrenheit.	Bottom Temperature, Fahrenheit.
	° ′	° ′		°	°
46	59 23	7 4	374	53·9	46·0
47	59 34	7 18	542	54·0	43·8
48	59 32	6 59	540	..	..
49	59 43	7 44	475	53·6	45·4
50	59 54	7 52	355	52·6	46·2
51	60 6	8 14	440	51·6	42·0
52	60 25	8 10	384	52·1	30·6
53	60 25	7 26	490	52·1	30·0
54	59 56	6 27	363	52·5	31·4
55	60 4	6 19	605	52·6	29·8
56	60 2	6 11	480	52·6	30·7
57	60 14	6 17	632	52·9	30·5
58	60 21	6 51	540	51·4	30·8
59	60 21	5 41	580	52·7	29·7
60	61 3	5 58	167	49·5	44·3
61	62 1	5 19	114	50·4	45·0
62	61 59	4 38	125	49·6	44·6
63	61 57	4 2	317	49·0	30·3
*64	61 21	3 44	640	49·7	30·0
65	61 10	2 21	345	52·0	30·0
71	60 17	2 53	103	53·0	48·6
72	60 20	3 5	76	52·3	48·8
73	60 29	3 6	84	52·7	48·8
74	60 39	3 9	203	52·6	47·6
75	60 45	3 6	250	51·5	41·9
76	60 36	3 58	344	50·3	29·7
77	60 34	4 40	560	50·9	29·8
78	60 14	4 30	290	52·2	41·5
79	59 44	4 44	76	52·1	48·9
80	59 49	4 42	92	53·2	49·4
81	59 54	5 1	142	53·3	49·1
82	60 0	5 13	312	52·3	41·4
83	60 6	5 8	362	53·1	37·5
84	59 34	6 34	155	54·3	49·1
85	59 40	6 34	190	53·9	48·6
86	59 48	6 31	445	53·6	30·1
87	59 35	9 11	767	52·5	41·4
88	59 26	8 23	705	53·5	42·6

"LIGHTNING" SOUNDINGS.

Station, No.	North Latitude.	West Longitude.	Depth, Fathoms.	Surface Temperature, Fahrenheit.	Bottom Temperature, Fahrenheit.
	° ′	° ′		°	°
1	59 20	7 5	500	54·5	46·5
2	60 32	9 10	164	54·0	48·0
3	60 31	9 18	229	54·0	47·0
4	60 41	8 45	72	54·0	49·0
5	61 1	7 48	62	53·0	50·0
6	60 45	4 49	510	52·0	31·0
7	60 7	5 21	500	51·0	30·0
8	60 10	5 59	550	53·0	29·8
10	60 28	6 55	500	51·0	30·8
11	60 30	7 16	450	50·0	31·2
12	59 36	7 20	530	52·5	44·8
13	59 5	7 29	189	52·0	48·5
14	59 50	9 15	650	53·0	43·0
15	60 38	11 7	570	52·0	43·5
16	61 2	12 4	650	—	—
17	59 49	12 36	620	52·0	43·5

* This number has been omitted by the Engraver. Its place is about midway between 63 and 65.

Table referred to in p. 238.

Temperature of the **Sea** at **Different Depths** in the **Channel** between the **North** of **Scotland**, the **Shetland Isles**, and the **Faroe Islands**; as ascertained by *Serial* and by *Bottom* **Soundings**. (N.B.—The Roman Numerals indicate the "Lightning" Temperature-Soundings, corrected for pressure.)

Warm Area.						Cold Area.						
Series 87.		Station No.	Depth.	Surface Temperature.	Bottom Temperature.	Series 64.		Ser. 52.	Station No.	Depth.	Surface Temperature.	Bottom Temperature.
Depth.	Temperature.					Depth.	Temperature.	Temperature.				
faths.	°		faths.	°	°	faths.	°	°		faths.	°	°
0	52·6					0	49·7	52·1				
50	48·1	73	84	52·7	48·8	50	45·5	48·5	70	66	53·4	45·2
		80	92	53·2	49·4				69	67	53·5	43·8
100	47·3					100	45·0	47·3	68	75	52·5	44·0
		71	103	53·0	48·6				61	114	50·4	45·0
		81	142	53·3	49·1!				62	125	49·6	44·6
150	47·0	84	155	54·3	49·2	150	43·3	46·5	60	167	49·5	44·3
		85	190	53·9	48·7				IX.	170	52·0	41·0
200	46·8					200	39·6	45·6				
		74	203	52·5	47·7							
						250	34·3	38·4				
300	46·6					300	32·4	30·8				
									63	317	49·0	30·3
									65	345	52·0	29·9
									76	344	50·3	29·7
		50	355	52·6	46·2	350	31·4	..	54	363	52·5	31·4
		46	374	53·9	46·0	384	..	30·6				
						400	31·0	..	86	445	53·6	30·1
400	46·1											
		89	445	53·1	45·6	450	30·6	..				
		90	458	53·1	45·2				56	480	52·6	30·7
		49	475	53·6	45·4				53	490	52·1	30·0
500	45·1					500	30·1	..	X.	500	51·0	30·8
		XII.	530	52·5	44·3				58	540	51·5	30·8
		47	542	54·0	43·8				VIII.	550	53·0	29·8
		XV.	570	52·0	43·5	550	30·1	..	77	560	50·9	29·8
									59	580	52·7	29·7
600	43·0					600	29·9	..				
		XVII.	620	52·0	43·5				55	605	52·6	29·8
		XIV.	650	53·0	42·5				57	632	52·0	30·5
						640	29·6	..				
700												
		88	705	53·5	42·7							
767	41·4											

Description of Plates.

Plate I.—Holtenia Carpenteri.

Plate II.—Fig. 1. Vertical section of Holtenia Carpenteri, showing oscular cavity and general arrangement of sponge, substance $\frac{1}{2}$ N. S.

2. A portion of the outer wall, showing stellate arrangement of siliceous spicules and ultimate sarcode network, with inhalent pores.

Plate II.—Fig. 3. Section of one of the trabeculæ of the substance of the sponge, showing the origin of two of the fascicles of spicules of the beard, which pass through the outer rood of the sponge at *a* and *b*. × 10.

4. Amphidiscus spicule. × 600.

5 and 5*a*. Feathered spicule of the sarcode from network of outer rood. × 200.

6. Hamate spicule from fascicle of the beard. × 150.

7. One of the smaller quinque-radiate spicules from network of oscular cavity. × about 13.

8. Small portion of long simple spicules of beard.

9. Spiny spicule from margin of osculum.

10. Large quinque-radiate spicule of outer network. × about 13.

11. One form of hamate spicule from fascicle of beard. × about 13.

12. Another ditto.

13. Large quinque-radiate spicule from outer network. (See also 10.)

14. Portion of delicate silky fibre from neighbourhood of osculum.

15. Fusiform spicule of sarcode from inner sponge substance. × 125.

16. Holtenia Carpenteri, young. × 5.

17. Oscular surface of ditto.

18. Hex-radiate feathered spicule, probably from netted lid of Aphrocaclistes.

19. Part of wall of oscular cavity.

20. A younger specimen than Fig. 16.

(The preceding illustrations are taken from "Phil. Trans."

Woodcut of Rhizocrinus Lofotensis, page 350.

THE TOTAL ECLIPSE OF THE MOON.

BY JOHN BROWNING, F.R.A.S.

THE early part of the eclipse was not visible at my telescope, in consequence of the very low altitude of the moon. When the moon became visible about 9 p.m. the sky was still very light, yet from the first moment of visibility it was distinctly seen that the eclipsed portion of the moon was of a full copper-colour. On repeated examinations and comparisons of tints, I could not better describe the ruddy colour I saw. This colour increased in intensity as the total phase approached, but it was only when the moon began to emerge from the shadow that the full display of colour became visible. At this time the uneclipsed crescent appeared of a bright lemon-yellow colour, while to the extent of one-third of the moon's diameter the surface was of a fine bluish grey, very different from the general hue of the lunar surface when seen uneclipsed. This colour gradually merged into a coppery tint, which at the portion of the limb opposite the bright crescent was of a deep chocolate.

Circumstances prevented me from attempting the careful measurement of the absorption lines in the spectrum, specially due to vapour. These were easily recognized on the comparatively bright portions of the moon's surface, but during the time of total obscuration I could not obtain any of these lines with sufficient sharpness to even make drawings of them, though I used a telescope of above 12 inches in aperture, and a spectroscope in which the spectrum was only magnified between two and three diameters. I used a very wide slit, and the spectrum seen in this manner at the time of total obscuration consisted only of the red and orange portions of the spectrum, with a mere trace of the green, not, I think, extending as far as little B in the spectrum. From B to midway between D and E a large number of cloudy bands were visible. On any attempt to close the slit sufficiently to produce sharp definition, the spectrum became so dark that the bands were themselves lost.

To observe the eclipse I used an achromatic eye-piece, having a field of nearly 2°, and magnifying about forty diameters.

STAR-DRIFT.

BY RICHARD A. PROCTOR, B.A., F.R.A.S.,

Author of "Saturn and its System," etc., etc.

Of all the discoveries effected by Sir W. Herschel, none gave greater evidence of his skill in dealing with observed facts than his discovery that the solar system is sweeping onwards with enormous velocity through the intersidereal spaces. The problem had been attacked a year or two before by an eminent German astronomer without success. Mayer had, indeed, announced definitively that the stellar motions afford no evidence to countenance the view that our Sun is speeding through space. No other evidence lay before Herschel than Mayer had possessed, nor was there any flaw in Mayer's mode of reasoning. Undoubtedly the full evidence which Herschel had to deal with was unfavourable to the idea of solar motion. But no one knew better than Sir William Herschel that in questions of this sort old Hesiod's proverb is applicable, that "Half is often more than the whole." By throwing aside half the evidence, though that evidence already seemed sufficiently meagre, he deduced a result which all the exact and recondite processes of recent inquiry have scarcely been able to improve upon. He pointed to a certain region among the stars as that towards which our Sun is travelling, and around that region all the best determinations of modern times have ranged themselves. I have before me, as I write, a map in which I have laid down all the points which Mädler, and Airy, and Argelander, and Struve, have successively indicated as the apex of the sun's path in space. These points cover a region of the heavens some twenty degrees in length and some ten degrees in width; but the last and best determination, the result of a new process invented by the Astronomer Royal, and applied (under the able superintendence of Mr. Dunkin, of the Greenwich Observatory) to no less than 1167 stars, lies within three degrees of the spot which Herschel pointed to nearly a century ago.

It is easy to recognize the justice of the principle on which Sir William Herschel proceeded; and the subject is so intimately associated with that which I am about to discuss, that a brief sketch of his mode of dealing with the solar motion will not be out of place here.

The only evidence we can have respecting the movements of the Sun is that to be derived from the apparent motions of the

objects which surround him. There is no irregularity in his stately progress through space to enforce upon us who move with him the fact that he is not at rest. But the stars which lie on all sides around his path, must be affected with apparent motions unless they travel with him, not only in the same direction, but at equal speed. To the unaided eye no signs of stellar motion are apparent. There are not, indeed, ten stars in the heavens whose motion in a thousand years would cover an arc that the naked eye could estimate. But the skilfully constructed instruments in use in modern observatories enable the astronomer to measure even the seemingly evanescent movements of the so-called fixed stars. In ten years, or in twenty, no change of position may be apparent, but, when the observations of our day come to be compared with those which were made a hundred years ago, the traces of stellar motion become in many instances unmistakeable.

But here one point is to be noticed. A star's change of place, even in long intervals of time, is often so minute that instrumental errors may mask it. Instrumental errors may do worse, however: they may unduly magnify the star's proper motion, or seem to give proper motion to a star which in reality has none. An illustration will serve to give the reader some idea of the delicacy of observation required for the determination of stellar movements. Every one knows the seven bright stars of the Great Bear. They form a group called by some the Butcher's Cleaver, by others Charles's Wain. Now, if any one looks carefully at the middle star of the bear's tail, he will notice very close to it a tiny star.* The distance separating the bright star from its companion seems very small indeed; yet a star would be thought to have an unusually large proper motion which should traverse in a hundred years one-tenth of this tiny space.

The result of this is, that the less perfect our observations are, the larger do the stellar motions appear to be. A careless observation at one or other end of the long interval of time made use of, will cause a star to simulate a proper motion altogether disproportionate to its real movement on the celestial sphere. I am not theorizing, be it understood, on this point. The fact has been well established. I think it was Argelander who remarked that the best proof of the value of a new catalogue of stars is the extent to which it reduces former estimates of the stellar proper motions. I have a proof of this immediately at my hand. I open the pages

* The Arabs called this star "the rider," and the power of discerning it was among them a recognized test of sharpness of vision; but now it is very easily seen.

of the celebrated "Star Catalogue of the British Association," and, running my eye down a column of proper motions, I select the ten largest. I find that out of the ten stars thus conspicuous for large proper motions, no less than seven belong to the southern heavens, or, in other words, to the part of the celestial sphere which has been least carefully surveyed. The inference is obvious.

Now, Sir William Herschel felt that if he made use of assigned proper motions which were in reality due to carelessness of observation, the result would be vitiated. He saw that to multiply the number of stars he considered was to multiply the chances of an erroneous determination. Nay, if the proper motions of ten stars could be trusted, and a hundred doubtful proper motions were dealt with at the same time, it was all but certain that no satisfactory result could be obtained. Mayer's failure served to prove this.

What Herschel did then was to select only those proper motions which by their exceptional magnitude were safe from the influence of observational errors. To a few of these he trusted, paying no attention whatever to doubtful proper motions. The result was that he succeeded where Mayer, after much more labour, had signally failed. Like a master-bowman Herschel seemed to aim carelessly at the mark, yet struck it fair and full.

But even as Herschel saw the great truth he sought to establish shining clearly forth from amidst the gloom in which it had hitherto been enshrouded, he became conscious of other great truths which stood beside it. With two of these we are now principally concerned, and though as yet science has done little to present either of them in their just proportions, yet we know enough already to believe that they will hold a noble place in the science of future ages.

Our Sun, sweeping ever onwards through space, tells us of a great law of motion to which his fellow-suns also must be subject. He is but one among many, when viewed in relation to the galactic system. Nay, it is doubtful even whether among the Suns which shine upon us from beyond the vast domain over which our own Sun bears sway, there be not many which as far surpass him in magnitude as the giant members of the solar scheme—Uranus and Neptune, Saturn and Jupiter—surpass our tiny Earth and its fellows among the minor planets. Nor is there aught in the Sun's position to lead us to ascribe to him alone swift motion throughout space. That, as *we* view the galaxy, he seems to occupy a central position is true enough; but it is conceivable if not certain, that there is not a single Sun among all the stars which deck our skies, from

which the same sort of scene is not visible, as that which is presented to the inhabitants of our Earth.

And this is not all. The very evidence Sir William Herschel had made use of proved that our Sun is not the sole moving star of the galaxy. Had he been able, by assigning a certain direction to the Sun's motion, to have accounted for the motions of all the stars his processes dealt with, he might then indeed have inferred the possibility that those stars at least are at rest. But this was not the case. The direction he assigned to the Sun's motion was that which accounted best for the stars' motions, not that which explained them fully. The balance of motion which remained unaccounted for could be explained only by supposing that the stars Herschel had considered were themselves sweeping rapidly through space. This view was directly involved in the statements Sir William Herschel laid before the scientific world.

This was one of the great truths associated with Herschel's noble researches; and it is the one with which we are here most immediately concerned. But there was another which must be considered before we proceed to examine the evidence we have respecting the nature of the stars' proper motion, and particularly the evidence which justifies my description of the sidereal movements as star-drift.

If the Sun is moving now in a definite direction, it can by no means be inferred that his motion will always continue to be directed towards the same region of space. All the analogies which surround us teach us to believe rather that his path is of the nature of a gigantic curve re-entering into itself mayhap like the planetary orbits, or possibly of a complex figure, resembling the paths of those comets which belong indeed to the solar scheme, but are swayed continually into new orbits by the attractions of the larger planets. Whichever of these views is correct, it is certain that the part of his path which the Sun is at present describing, must be looked upon as a portion of a gigantic circle. For, no matter what the figure of an orbit may be, any small portion of the curve may always be regarded as belonging to some definite circle. And astronomers have set themselves to inquire into the nature of the vast circle on which, for present purposes, we are to regard the Sun as travelling.

The ingenious German astronomer Mädler, by a process of inquiry, which I could not describe in full without diagrams, has been led to regard the star Alcyone, the "brilliant" of the Pleiades, as the true centre of the Sun's motion. Without pretending to

render the principle of his researches perfectly obvious to the general reader, I may yet briefly state how he has deduced a conclusion of so much importance.

He argues that if the galaxy has a centre within the range of the visible stars, a certain peculiarity must mark the motions of the stars which lie nearer to the centre than our Sun does. As has been already mentioned, the neighbourhood of the centre of a stellar system is a scene of comparative rest. In the solar system we see the planets travelling faster and faster, the nearer they are to the great ruling centre of the scheme; and the reason is very obvious. The nearer a body is to a great centre of attraction like the Sun, the greater is the attraction to which it is subject, and the more rapid must its motion be to enable it to maintain itself, so to speak, against the increased attraction; but in a vast scheme of stars tolerably uniform in magnitude and distribution, the outside of the scheme is the region of greatest attraction, for there the mass of all the stars is operative in one general direction. As we leave the outskirts of the scheme, the attraction towards the centre becomes counterbalanced by attractions towards the circumference; and at the centre itself there is a perfect balance of force, so that a body placed there would remain in absolute rest. It is clear, then, that the nearer a body is to the centre, the more slowly it will move. This being so, all stars which lie nearer than the Sun to the centre must move more slowly than the Sun; and therefore, whatever the direction of their motion, they must *lag behind* as seen from the Sun!

So that if we can detect, in any part of the heavens, a community of motion, in a direction opposite to that of the Sun's motion, we may take it for granted (on the assumptions involved in Mädler's argument) that the centre of the sidereal scheme lies in that part of the heavens.

Now Mädler noticed that, in the constellation Taurus, there is such a community of motion as he had described; and carefully estimating the amount of motion observed among the stars of different orders of magnitude, he thought he saw reason for assigning to Alcyone a condition of absolute rest.

Here, then, if his assumptions were correct, we were to recognize the central orb of the sidereal scheme; not, indeed, the central orb in the sense in which our Sun is the central orb of the solar scheme; not a globe which, by its magnitude, could be held to sway the motions of all the stars which lie around it. Alcyone, according to Mädler's theory, is simply the star which occupies the

centre of the sidereal scheme, but without rule or governance over its fellow-stars.

These speculations of Mädler's form, I believe, the sole attempt which has yet been made to co-ordinate the motions of the stars into one systematic whole. They have not been looked upon as successful, nor has the consideration of the subject led astronomers to believe that the problem Mädler attacked is one which *can* be mastered in the present state of our knowledge.

The objections which have been urged against Mädler's speculations are too numerous and important to be overlooked. In the first place, his assumption that there is a central orb within the range of the visible stars, is one which is at present wholly inadmissible. There is nothing in the appearance of the heavens to lead us to suppose that the centre of the sidereal scheme is in our neighbourhood (so to speak). Rather we should be led, as the celebrated German astronomer, Struve, long since pointed out, to regard the distance which separates the Sun from the faintest of the lucid stars as altogether evanescent in comparison with the Sun's displacement from the centre of the galaxy. Again, Mädler's mode of treating the question involved the supposition that all the stars travel in almost circular paths around the centre of the sidereal scheme, since any great eccentricity in their orbital motions would involve a total change in the character of their motion at definite distances from the centre. Then he assumed a knowledge, on our part, of the distances of stars of different degrees of brightness, which was altogether more exact than any we can really pretend to possess. These and other considerations have led all the most eminent of our modern astronomers to look upon Mädler's hypothesis as one which, in the present state of our knowledge, we have no right to look upon with favour.

To these arguments I am able to add another which has hitherto, I believe, escaped notice,—the fact, namely, that the community of motion which Mädler noticed in Taurus, and which he supposed to be exceptional, is in reality a feature commonly to be met with among the stars, and is, in fact, simply an illustration of that peculiarity which I have ventured to designate by the name of "star-drift."

Let us return, however, to the stellar motions which the searching eye of Sir William Herschel had detected at an early stage of the inquiry.

As the apparent motions of the stars were examined with greater and greater care, it became more and more evident that every star is rushing swiftly through space; for, although every fresh deter-

mination of the nature of the Sun's motion showed a general agreement with Herschel's result, yet there was a sufficient divergence to prove that some causes other than variations in the method of calculation are at work in causing the discordance.

But it is only in comparatively recent times that it has been shown demonstratively, how largely the apparent motions of the stars are due to the real movements of these bodies in space. The Astronomer Royal commenced, in 1859, a process of inquiry which was at once more rigid and more complete than any which had hitherto been applied to the subject. The principle of the new mode of inquiry was remarkably simple. Mr. Airy argued that, if we are to obtain a really conclusive answer to the great question of the Sun's motion in space, we must remember that the stellar motions, though apparently taking place upon the celestial sphere, have really no relation at all to that imaginary surface. We must look upon them, he said, as taking place in reality in space, and apply to them the mathematical processes which result from that consideration. It need hardly be said that, as we know nothing of the motions of recess or approach which stars may have—though the spectroscope, in the able hands of Mr. Huggins, promises soon to remove that defect in our knowledge—the whole question becomes one of probabilities. But we can deal mathematically with probabilities of this sort, and thus deduce from a number of observed relations, whose actual significance is uncertain, the result which is mathematically the most probable. This was the problem which Airy solved, and it cannot be doubted that the solution of a problem so complex and perplexing is one of the most notable triumphs which modern astronomy has achieved.

With the solution of this problem, however, came several unlooked-for difficulties.

The point towards which the Sun was found to be moving, accorded most satisfactorily with the results which had been obtained by other modes. The rate assigned to the solar motion was also in close accordance with that which the younger Struve had obtained by a different process. I may mention in passing what this rate is, because it is important that we should have clear notions respecting the amount of motion which we may look for among the members of the sidereal system. It appears, then, from the researches of Otto Struve on the one part, and those of the Astronomer Royal and Mr. Dunkin on the other, that the Sun is moving at the rate of about a hundred and fifty millions of miles per annum. Although this velocity seems enormous, it is in reality smaller than the

velocities we notice in many parts of the solar system. Our own Earth moves more than three times as fast in her orbit, as the Sun on his path through space. Indeed, the diameter of the Earth's orbit is thirty millions of miles greater than the distance annually traversed by the Sun.*

So far the results of the Astronomer Royal's researches were in close accordance with the views already entertained by astronomers. But in the progress of the inquiry certain processes had been performed upon the tabulated proper motions of the stars, which rendered it easy to apply an interesting test to the theory of the Sun's motion, or rather to the power which that theory may have of accounting for the stellar motions. It was possible in fact to apply the effect due to the Sun's motion in space, as a correction to the stellar movements. It seemed clear that if this were done, the result should be that the total amount of apparent motion would be largely diminished. If a person is moving rapidly amidst a crowd of moving persons, the appearance of movement in the crowd is in general much more striking than it becomes when he stands still; and what the Astronomer Royal was really doing—or rather what he was theoretically doing—was to make the stars' motions such as they would be if the Sun were suddenly reduced to rest.

But the result of these processes was not that which the Astronomer Royal had looked for. The stellar apparent motions, instead of being considerably reduced by the change, remained very nearly as large as they were before.

Speaking of this result nearly a year after the Astronomer Royal's labours had been published, Mr. Main, then President of the Royal Astronomical Society, remarked that "the inevitable logical inference deducible from Mr. Airy's researches, is that the whole question of solar motion in space, so far, at least, as accounting for the proper motions of the stars is concerned, appears to remain in

* The peculiarity of the Earth's real motion in space, when her orbital motion is combined with the Sun's progressive motion, has proved a source of strange difficulty to many persons, ever since Sir William Herschel announced his solution of the problem of the Sun's motion. Although Newton had provided for the possibility of the Sun's motion, many imagine that the Newtonian theory of gravitation, and the Copernican theory itself are endangered by the complexities thus introduced into the solar system. It need hardly be said that the question of the path actually pursued by the Earth in space is merely one of curiosity, the orbital motions of the Earth being absolutely unaffected by the progressive motion which she shares with the Sun. As a matter of fact, it is worth mentioning that the Earth's path in space resembles the thread of a screw having a skew axis—the direction of the Sun's motion being inclined about fifty-four degrees to the plane of the Earth's orbit.

doubt and abeyance." It must be understood, however, that the doubts here expressed by no means rest upon the fact of the Sun's motion. We are forced to believe that *some* of the assumptions upon which we had been proceeding with confidence, are more than questionable. It may be, for example, that our ideas of the stellar distances require to be modified. Or again, it may be that the stars are not moving independently, but according to some system which tends to falsify all the general assumptions we had formed on the hypothesis that they are independent Suns like our own. And, again, there may be laws of motion which associate the stellar movements in a special manner, without any actual association of the individual orbs.

I was led some time ago, by considerations wholly distinct from those which I have been dealing with above, to form the opinion that if the proper motions of the stars were *mapped*, there would be rendered apparent signs of association between stars much farther apart on the heavens than the members of the widest double or multiple star-systems. In the STUDENT for March, 1868, I pointed to the fact that associated proper motions would afford significant evidence in favour of the theory that the signs of stellar aggregation in certain parts of the heavens are not accidental.

I therefore proceeded to map down the proper motions which the Astronomer Royal had used in his calculations. It need hardly be said that a map of proper motions speaks much more intelligibly and clearly respecting the meaning of those motions than the most carefully constructed table could do. Astronomical tables are necessarily arranged in such a way that stars which lie near each other in the heavens are often far apart in the catalogues. It is therefore impossible to form any clear conception of the general character of the motions prevailing in any given region of the heavens. When a chart had been so constructed as to exhibit the stellar motions to the eye, this difficulty was at once removed.

The plan I adopted was to attach to each star a little arrow, whose direction and length indicated the character and magnitude of the star's proper motion. In order that these arrows might not be too small, I had to give them the length corresponding to the star's motion during a very long interval of time. For convenience, I made one degree on the map correspond to a stellar motion of one-tenth of a second; the result being that the motions actually represented were those which would take place in the course of 36,000 years. Even so magnified, most of the motion-arrows were inconveniently minute.

The maps included at first only the 1167 stars dealt with by the Astronomer Royal, but I subsequently added upwards of 400 stars, whose proper motions had been calculated by Mr. Stone, of the Greenwich Observatory, from observations as trustworthy (having, in fact, been made by the same observers) as those which Mr. Main had used in preparing the catalogue of 1167 stars.

The maps, which I have before me as I write, fully justify the term "star-drift," which I have applied to the stellar proper motions.

Remembering that the stars which are visible to us lie at very different distances, we see that if a real star-group exists in space, with real dimensions which cause it to appear to cover a widely-extended region of the heavens, we must expect to find that other stars in the same region do not belong to the group. Not only so, but it must be looked upon as highly probable that the stars seen in any given direction may belong to three, four, or more star-groups, if the existence of star-groups is a real fact. Therefore we might expect the existence of star-groups to be more or less masked by the effects which would follow from their apparent intermixture. If, for instance, a general concurrence of proper motions in a definite direction is to be held indicative of the fact that the stars so moving form a single system, then we might expect in general to fail in detecting such systematic drift, on account of the perplexities introduced by some other drift belonging to a set of stars apparently mixed up with the former. And if three or more star-drifts were mixed up together in this way, the problem would become still more perplexing.

Thus, all that was to be hoped for (as it seemed), was that here and there some sufficiently well marked cases of star-drift might not be masked by the effect of other motions.

The result, however, was more satisfactory than I had anticipated.

In some regions large groups of stars are seen to be drifting bodily in a definite direction. The most remarkable instance of this sort occurs in the stars which form the constellations Gemini and Cancer. All these, amounting in number to seventy or eighty, are drifting towards the neighbouring part of the Milky Way, with the exception of three stars, which seem to belong to another system. Another remarkable instance is to be found in the stars of the constellation Taurus. This is the instance of concurrent proper motions on which Mädler founded his theory that Alcyone is the central sun of our galaxy. The drift in this part of the heavens is in a manner opposed to that in Cancer and Gemini. The two

systems are, in fact, divided by the Milky Way, and each seems drifting towards that zone.

More commonly, however, two or three forms of star-drift are seen intermixed in the same region of the heavens. And here it might seem difficult to pronounce whether in reality there are any associated movements, since it would clearly not be impossible that a mere chance distribution of motions might simulate a tendency towards two or three definite directions. There is, however, a circumstance which at once serves to establish the true significance of the observed relations. If the motions in one *direction* have, besides, a general agreement in respect of *magnitude*, we can clearly assume with a much greater degree of probability that they indicate a real drift, or, rather, that the stars they belong to form a real system. Nay, the mere fact that a number of stars in a given region have a very minute proper motion, while all the rest have large motions, would show that the former form a system perfectly distinct from the latter. One instance will serve to show the power of this new mode of discrimination.

Of the seven bright stars in the Great Bear, five are travelling in a common direction with uniform velocity. The other two are travelling in another direction, and also with a common velocity. We cannot doubt that the first five, at any rate, form a system, drifting along bodily. For let us sum up the evidence. First, we have the comparatively weak evidence derived from the general equality of the five stars, a peculiarity which has in all ages led observant men to entertain the impression that these stars are in some way associated. Next, we have the fact that the five stars are travelling in the same apparent direction, and the significance of this point it is easy to estimate, because the antecedent probability that, taking the direction of one star of the five as a standard of reference, the other four would be found to be travelling in the same direction, is demonstrably minute. Lastly, we have the evidence derived from the equality of the motions of the five stars, and here again the antecedent probability of the coincidence is so minute as to force upon us the opinion that the actual coincidence is not accidental. The combination of the three lines of evidence leads to a feeling of absolute certainty that the five stars are associated into a single scheme or system.

Let us pause for a moment to contemplate the significance of this result. One of the stars of the set of five is the middle star in the tail, which I have already referred to as having a companion visible to the naked eye. Now, it had long since been proved that

the bright star and its small companion are really connected. The evidence had been no other than that community of proper motion which I have been dealing with in the case of the five stars. Mizar and Alcor, then, were looked on as a wide double, and astronomers had contemplated with interest and amazement the wondrous cycle corresponding to the motions of stars separated in reality by an enormous interval. For the nearest of the stars in our northern skies is more than 720,000 times farther from us than we are from the Sun. Mizar is presumably much farther away. Now, whatever distance separates Mizar from us, cannot be more than about 240 times as great as that which separates Alcor from Mizar; so that Alcor must be at least 3000 times farther from its primary orb than we are from the Sun. How enormous, then, must be the period required for the revolution of the two stars around their common centre of gravity!

But this is not all. Mizar has a close companion, as well as its distant companion, Alcor. This close companion has the same proper motion as Alcor and Mizar, and belongs, therefore, to the same scheme as the other four stars. A sort of dignity is thus given to the star-system we are considering, by the triplicity of one of its members. At present, however, we are dealing with another consideration—the magnitude, namely, of the cyclic period appertaining to the scheme. Now, the close companion of Mizar, though undoubtedly it is in reality travelling round that star, moves yet so slowly that no sign of a change of place has as yet been detected by astronomers. Therefore the period of revolution, even for this comparatively close pair, must be very large, and Alcor must have a very much longer period; so that we may accept without surprise Baron Mädler's estimate that Alcor occupies no less than 7659 years in travelling around Mizar.

But what sort of periods can we assign to the cyclic revolutions of the five stars, when the comparatively close companions of one of the set occupy periods of revolution so enormous. Again, how can we resolve the questions which at once suggest themselves respecting the relations which prevail in such a system. That the whole system revolves around its centre of gravity is of course certain. But there are numberless ways in which the revolution may take place, depending on the relations between the weight and magnitude of the different orbs forming the system. Any two of the five may really form a pair, any three may form a triplet. We cannot tell where the centre of gravity of the scheme may be. We have no knowledge of the true relative positions of the five orbs.

We cannot guess what the real direction of their orbital motions may be. We are, in fact, altogether in doubt on every subject connected with the system, except the main fact that the whole system has a drift carrying it bodily forwards at the rate of many millions of miles per annum. It is in this relation that the appearance of such systems as these in the heavens, seems to me so interesting—I may almost say, so imposing a phenomenon. The life of man is a period too short to tell us anything even of the subordinate motions of such a scheme,—the motion of Mizar's companion about its primary, or of Alcor about both; but the duration of the human race, nay, of the solar system itself, may be outlasted by a single revolution of the great star-system placed out yonder in the celestial depths. From the far-off times of the Chaldæan shepherds the great Septentrion star-system has looked down with seemingly unchanging aspect on the rise and fall of many nations and races of men. When the human race has perished from this globe, when the earth has become what the moon now is, a scene of utter barrenness and desolation, the star-system will doubtless have exhibited many changes. But only when millions of æons have passed, and the earth is nearing the scene of its final absorption beneath the solar oceans, will the stately motions of the star-system have begun to work out the full series of cyclic changes appertaining to a scheme so extensive and so complicated.

But the star-drift in Ursa Major is only one instance out of many. Looking more closely than we have yet done into the sidereal scheme of which our Sun is a member, we see it breaking up into subordinate star-systems of greater or less extent. Our Sun himself may not be a solitary star as has been commonly supposed. From among the orbs which deck our skies, there may be some which are our Sun's companions on his path through space, though countless ages perhaps must pass before the signs of such companionship will be rendered discernible. On every side we see drifting star-schemes, and comparatively few stars are to be recognized as voyaging in solitary state through space. From the complexity of such systems as we see in Gemini and Cancer, to schemes such as the one in Ursa Major, and thence to solitary stars such as Arcturus and Sirius appear to be, we recognize a number of gradations, and it yet remains to be determined to what class of these schemes our Sun belongs.

Verily much remains to be learned respecting our galaxy. Since the days of Sir W. Herschel, or rather since the younger Herschel completed the noble series of labours commenced by his father, a

sort of rest has fallen upon astronomy, so far as the science deals with the relations of the great sidereal system. But there is room for much new labour in this wide field of research. The Herschels dealt with generalities. They discussed the galaxy as a whole, and it was no part of their work to examine into the details of the stellar scheme. The work they took in hand to do they accomplished with marvellous success, insomuch that they have left little for others to accomplish in the same direction. But it would be a mistake to renew the Herschelian mode of inquiry—to continue to neglect details and consider only the grander features of the galaxy. The work of survey has been completed. In examining, part by part, the field which has been plotted out for us, we must adopt new principles for our guidance. To deal, *now*, with generalities alone, as the Herschels did, would be to destroy those scarcely recognisable indications which can alone guide us to new knowledge. We must in future examine the sidereal scheme detail by detail, feature by feature. The work will not be light, and many workers will be wanted. But the result will be worth the toil. Not in our day, perhaps not for many generations, may the fruits of such labours be reaped. But gradually astronomy will gather in her harvest, and when it is garnered, the rich reward of many years of toil will be found in a clear knowledge of the relations presented by the wondrous galaxy to which our Sun belongs.

THE SARGASSO SEA, AND ITS INHABITANTS.

BY CUTHBERT COLLINGWOOD, M.A., F.L.S., ETC.

(*With a Plate.*)

AMONG the many remarkable phenomena connected with the Gulf Stream, not the least remarkable is the existence of those vast floating meadows of sea-weed, commonly known as the gulf-weed, or Sargassum; whose accumulations, within certain parallels of latitude and longitude, have given to that area, the name of the Sargasso Sea. These marine prairies, as they have been called, have attracted the notice of all navigators since the time of Columbus, who, in his first voyage, received his earliest check, upon falling in with them. The great pioneer entered the Sargasso Sea in lat. 26° N., and long. 48° W., and his timid shipmates at once took fright at the marvellous appearance, feeling assured that their ships would be entangled in the weed, until they were starved to death, or that they were about to strike on some unknown coast. In this part, he says, "the sea was covered with such a quantity of sea-weed, like little branches of the fir-trees which bear the pistachio nuts, that we believed the ships would run aground for want of water." They could not understand how such vast quantities of vegetation could merely float on the surface, and the appearance of a lobster among the weed, confirmed their fears —and deeming it necessary that they must be either in, or approaching, shoal water, they entreated the heroic discoverer to turn the ship's head. But, happily, he never wavered, and on the tropic, in long. 66°, the first vessel which had ever entered the Sargasso Sea, emerged again into clear water.

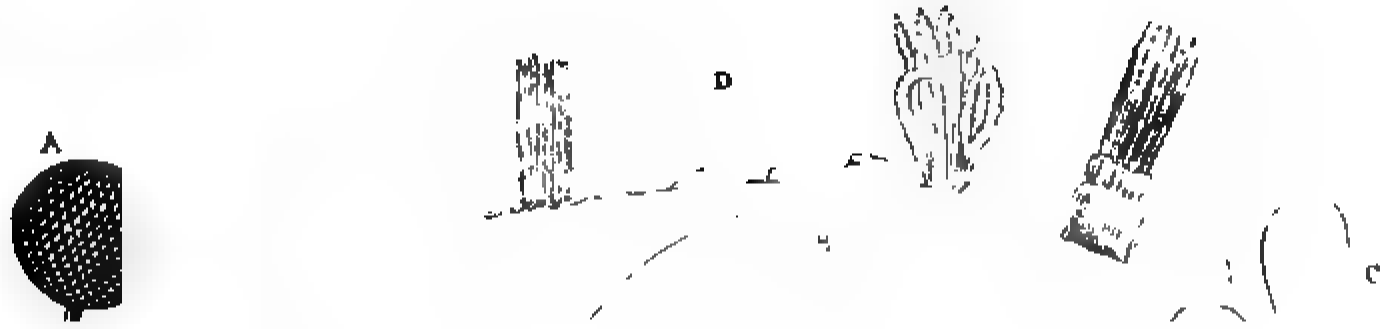
The extent of the Sargasso Sea is in due proportion to the vast natural agency to which it primarily owes its existence. It stretches from 20° to about 65° West longitude, and between the parallels of 20° and 45° is of considerable width, narrowing from 12° in its widest part, to about 4° or 5° where least developed; while the remaining 20° of westerly extent, takes the form of a narrow belt of various detached tracts, influenced as to situation, by local currents, and averaging 4° or 5° only in width. An idea may be obtained of its area, by the comparison of Maury, who states that it is equal to the great valley of the Mississippi; or still better, perhaps, from Humboldt's estimate, that it was about six times as large as the Germany of his day.

But, although the geographical boundaries given above are those usually recognized by hydrographers for the Sargasso Sea, it

must not be supposed that they are invariable. The writer first encountered it in lat. 24° N., and long. 36½° W. on July 1st, and lost it a week after, in lat. 35°, long. 34°, so that the whole area was nearly 5° further north than it is usually placed in the maps. It may, however, be correctly stated, that it occupies the great sweep made by the Azores, Canaries, and Cape de Verd Islands, in the East; while the elongated westerly belt extends as far as between the Bermudas and West India Islands.

The earlier navigators often found the gulf-weed a serious impediment to their progress. Lærius mentions that for fifteen continuous days he passed through one unbroken meadow (*Praderias de yerva,* or sea-weed prairies, as Oviedo characteristically calls them), so that he could find no way through for oars. On certain occasions it has been found that the speed of vessels through the Sargasso Sea has been materially retarded; and it has been described as so thick, that to the eye, at a little distance, it appears to be substantial enough to walk upon. James Barbot, Jun., voyaging to India in the year 1700, says:—"Twenty or twenty-five leagues west of Cabo Branco, we often see the ocean almost all over covered with a certain weed of a yellow-green colour, called Sargasso, resembling that which grows in our wells, or samphire, bearing a sort of seed at the extremities, which have neither substance nor savour. No man can tell where these weeds take root, the ocean being there so deep; they are also seen thus floating on its surface, sixty leagues to the westward of the coast of Africa, for the space of forty or fifty leagues, and so close and thick together in some places, that a ship requires a very fresh gale of wind to make her way through; and, therefore, we are very cautious to avoid them in our course."

That this is not the condition met with under all circumstances, is proved by the fact that passing through this region in 1867, the writer made a seven days' voyage through its central portion, during which the sea was at no time covered with the weed, so as to form a continuous meadow. It made its appearance usually in large patches, generally upon the surface, but sometimes apparently sunk to some distance below it. It varied considerably in appearance—was sometimes dark-coloured, dense, and compact, and covered with berries; at others, pale and attenuated, with few berries. The masses, on some days, were round and shapely, and usually scattered somewhat indiscriminately over the surface of the sea. Occasionally only a few small tufts appeared for many hours; and on one day the only sign of its presence was a long narrow



INHABITANTS OF THE SARGASSO SEA

streak, extending across the ocean as far as the eye could reach, in the direction of the wind. The fact, indeed, is that the Sargasso Sea, dependent as it is upon a great physical phenomenon, changes its position according to the seasons, storms, and winds; its mean position remaining the same as it has been ascertained by observations during many years past. The Gulf Stream is the great power which maintains these marine pastures—a current whose impulse and origin, according to Humboldt, are to be sought to the south of the Cape of Good Hope—after a long circuit it pours itself from the Caribbean Sea and the Mexican Gulf, through the Straits of the Bahamas, and following a course from south-south-west to north-north-east, continues to recede from the shores of the United States, until further deflected to the eastward by the banks of Newfoundland, it approaches the European coast. At the point where the Gulf Stream is deflected from the banks of Newfoundland towards the East, it sends off branches to the south near the Azores. This is the situation of the Sargasso Sea.

Patches of the weed are always to be seen floating along the outer edge of the Gulf Stream. Now, if bits of cork, or chaff, or any floating substance, says Capt. Maury, be put in a basin, and a circular motion be given to the water, all the light substances will be found crowding together near the centre of the pool, where there is the least motion. Just such a basin is the Atlantic Ocean to the Gulf Stream; and the Sargasso Sea is the centre of the whirl.

The Gulf-weed itself has so peculiar a history, that it forms not the least remarkable point of interest in the description of the Sargasso Sea. It is one of the numerous species of the genus Sargassum, which is among the most natural and readily distinguished genera of the family of Fucaceæ.

The great cryptogamist, Agardh, enumerates sixty-two species of Sargassum, of which the one concerning which we are speaking is the *Sargassum bacciferum*, called *Fucus natans* by Linnæus, and *Fucus sargasso*, by Gmelin. The Spanish word Sargazo, or Sargaço, meaning sea-weed, supplies its common English name. Agardh's botanical description is brief, and as follows:—"*S. bacciferum*:—Caule tereti ramosissimo, foliis linearibus serratis, vesiculis sphæricis mucronatis, petiolis teretibus." A more modern, and English technical description of the Sargassum, is the following:—

Sargassum.—Frond furnished with distinct, stalked, nerved leaves; and simple axillary stalked air-vessels. Receptacles small, linear, tuberculated; mostly in axillary clusters, or racemes. Seeds in distinct cells.

The integument is leathery, and the general colour brown, of varying shades, sometimes light, and sometimes dark. The most striking peculiarity, on a cursory view, is the abundance of globular cells, which have been taken by the unlearned for fruit, but which are in reality merely receptacles of air, by means of which the plant not only floats upon the surface of the ocean, but also is enabled to support vast numbers of marine animals, which find shelter among its tangled fronds. Columbus, the first discoverer of the Sargasso Sea, described the meadows as yellow, like dry hay-seed, bearing leaves of common rue, with numerous berries which turn black in drying, like juniper berries. These berries have received the name of *raisins de tropique*.

The species of Sargassum only grow where the temperature is considerable, but they have a very wide distribution. Dampier says that he observed plants of it near the coast of New Holland; but they may have been an allied species. Agardh, however, speaks of it as inhabiting the Atlantic, Pacific, and Indian oceans. Sea-weeds in general have no particular geographical limits, but when a comparatively shallow sea offers conditions for their growth, the degree of exposure to light, and the greater or less motion of the waves, are very important elements in their distribution. Again, the depth of sea has with sea-weeds an effect parallel with that which the height of mountain sides has upon land plants—and the sea-weed we have to do with is confined to the *surface* of the ocean, and has its head-quarters in the tropical Atlantic. It is not wonderful, therefore, that plants of it are occasionally washed upon our own shores, although we can scarcely reckon it as a British sea-weed. It is not, moreover, altogether an useless weed, for it is said to be eaten in China, and to be used as a pickle, and in salads, in some parts of the East. The quantity of soda it contains, in common with other sea-weeds, renders it useful as a manure; and it is even in repute as a medicine in some countries, and among certain classes. Thus, in South America it is used as a remedy against strangury and some tumours, as *Sargassum vulgare* is used in calculus; and Rumphius relates that the German and Portuguese sailors are accustomed to use it for the same purpose, first macerating it in water, then boiling it and drinking the infusion.

There is one point in the natural history of the Sargassum, which has already been passingly alluded to, but which has excited the attention of all observers, and more particularly of botanists. It is the fact that the Sargassum is always found floating upon the deep

sea, and is yet destitute of any apparent means of propagation. Agardh remarked that no fruit nor root could be detected; and expressed his belief that it grew in the depths of the ocean, and was torn up by the waves. This belief was very general at one time, and it was supposed that the perfect plant was unknown; but that the Gulf Stream collected together the torn-off masses of its vesicular summits. Rumphius suggested that the Sargassum fed upon the fat exhalations and oily effluvia of dead fish, and other organic substances entangled in it. Even modern publications state that there is reason to think that it is first attached to the bottom of comparatively shallow parts of the sea; but the gulf-weed is never found so attached. It always floats; and is healthy and abundant in that condition, never exhibiting any organs of fructification, though constantly putting out new fronds. Humboldt at first supported this notion of the plant being detached by the Gulf Stream from its fixed position in the Gulf of Florida; but latterly that distinguished philosopher, guided by the observations of the eminent German botanist, Meyen, adopted the opinion that it originates and propagates itself in the Atlantic, where it is so abundantly found. Meyen, in 1830, passed through a considerable portion of the great band of gulf-weed, and he ascertained, as he states, from the examination of several thousand specimens, that it was uniformly destitute of root and of fructification. He therefore concluded that the plant propagates itself solely by lateral branches; denying at the same time that it is brought from the Gulf of Florida, as, according to his own observations, it hardly exists in that part of the Gulf Stream, near the great band, though found in extensive masses to the westward. Robert Brown, however, was of opinion that the shores of the Gulf of Florida had not been sufficiently examined to enable him absolutely to decide that it is not the original source of the plant. Sloane says he saw gulf-weed growing on the rocks of the shores of Jamaica, but the specimens in his herbarium, says R. Brown, belong to the ordinary form, and are alike destitute of root and fructification.

A closely allied species (*Sargassum natans*, or *vulgare*) has been found fixed by a discoid base or root, in the same manner as the other species of the genus; and since Meyen declares that he has found all Agardh's varieties of *Sargassum natans* among the gulf-weed of the Atlantic, and moreover, that he has seen what he regards as the gulf-weed, in a state of fructification, on the coast of Brazil, the legitimate conclusion from his statements seems to be, that this plant is merely modified by the peculiar circumstances in

which it has been so long placed. It is not yet known what other species of Sargassum are mixed with the gulf-weed, what proportion they form of the great band, nor in what state, with respect to root and fructification, they are found. Accurate information upon these points would be of considerable importance.

That the gulf-weed of the great band (says Robert Brown, from whose communication on this subject this information is chiefly derived) is propagated solely by lateral or axillary ramification, and that in this way it may have extended over the immense space it now occupies, is highly probable; and perhaps may be affirmed absolutely, without involving the question of origin, which he considered still doubtful.

It does not appear that any other species of Sargassum is originally destitute of roots, even those most closely allied to *Sargassum bacciferum*, though some of them are not unfrequently found both in the fixed, and in considerable masses in the floating state, retaining vitality, and probably propagating themselves in the same manner. The late Professor Harvey conjectured that the gulf-weed might be a pelagic variety of *Sargassum vulgare* in the same way as the variety *subcostatus* of *Fucus vesiculosus* has never been found attached, growing in salt marshes. In the Mediterranean, vast quantities of *Fucus vesiculosus* occur under a peculiar form, consisting entirely of specimens derived from sea-born weed, carried in by the current which sets in to that sea from the Atlantic. So also, says Balfour, *Fucus mackaii*, which has never been found attached, may be a form of *Fucus nodosus*, growing on muddy shores. The fact of the floating masses of Sargassum being barren, is strictly analogous to that of Macrocystis, producing fruit only on young attached specimens. In both cases, says Berkeley, multiplication is so rapid in the floating beds, as to render fruit needless; and the same great authority on cryptogamic botany, is of opinion that the same individual continually produces new branches and leaves, and thus multiplies the species; although he thinks there is not sufficient evidence to prove whether or no they receive fresh accessions from plants produced on rocks.

Wherever there are large accumulations of sea-weed, it necessarily follows that there should be a population of some kind supported by them. Speaking of the kelp (*Macrocystis pyrifera*), which, though rooted to the bottom, extends perhaps 60 fathoms from its anchorage, Darwin says, "The number of living creatures of all orders, whose existence intimately depends on the kelp, is wonderful. I can only compare these great aquatic forests of the

southern hemisphere with the terrestrial ones in the intertropical regions. Yet if in any country a forest were destroyed, I do not believe nearly so many species of animals would perish, as would here from the destruction of the kelp." And intelligent navigators have remarked the same of the gulf-weed. Capt. Grey, in his voyage from Australia, remarks, "In lat. 29° north, we entered a portion of the sea covered with patches of sea-weed, around which swarmed numerous eel-like fish, crabs, shrimps, and little blue fish. These last swarm under those floating islands, sometimes leaving them for a little distance—but they always returned, or swam to another. The crabs crawled in and out among the sea-weed, and other fish of a large size came to these spots to deposit their spawn; so that we were in an archipelago of floating islands, teeming with busy inhabitants and animal enjoyment." These masses of floating weed, indeed, serve as the retreat of an innumerable host of marine animals, of which some live in the midst of their inextricable labyrinths, and others having been once entangled in them, cannot escape, and are forced to abandon themselves to the current of these immense sea forests, in the midst of which they are enclosed.

On returning from China in 1867, it was my fortune to cross the Sargasso Sea early in July; and moreover, having several days of calm weather, I spent some time upon the chains, armed with a grapnel, by means of which I, from time to time, was able to raise bunches of sea-weed upon deck, for examination. Nearly every bunch of weed, so obtained, was found to be peopled with similar creatures, Polyzoa, Polyps, Annelids, Crustacea, Molluscs, and Fish; concerning the most remarkable of which, I shall, in concluding this paper, make a few observations. Though not absolutely connected with the weed, yet as occurring side by side with it in the same latitude, I may mention magnificent specimens of Physalia, or Portuguese man-of-war, which sailed by in the beautiful calms of that region—their blue-tinted bladders were eight inches long, and nearly three inches above the water—their long threads trailing beneath, and giving shelter to a number of little banded fishes, which seemed to find protection in this equivocal position. With these were Velellæ of a proportionately large size, and the clearer portions of the sea swarmed with large compound Ascidians of various curious forms, described in a former paper, and numerous remarkable Hydrozoa, many of which are yet undescribed.

The most characteristic appearance met with on the gulf-weed, of an animal nature, is, undoubtedly, those encrustations of a polypoid or polyzoid character, with which every frond abounds. The

multitudes of these minute inhabitants is literally incalculable. Every leaf is more or less covered with them—every berry is more or less changed from brown to a light buff or greyish tint, by means of the spreading vegetating polyzoaries, allied to what is known to us as the sea-mat (*Flustra*), though it is worthy of remark that the encrusting Polyzoa of the leaves and berries were of one species, and that of the stems of another. The great majority of these Polyzoa appear to be of the genus *Membranipora*, the cells of which are arranged in a quincuntial manner, with raised margins. These curious cells, and the social mollusks inhabiting them, afforded a constant object of interest for the microscope. Associated with them, were graceful *Campanulariæ*, lower in organization, but excelling them in beauty, with elegant goblet-shaped cups set upon moniliform stems, out of which protruded the bunch of tentacles, unprovided with the cilia, which are so prominent a character of the arms of Membranipora. On most berries also were the little spiral shells of tubicolous Annelids (*Spirobis*), whose branchial tufts appeared like elegant little plumes of feathers. Besides these, Vorticellæ, and many other minute forms of life, rewarded the microscopic observation of these fertile marine plains.

One of the most common inhabitants of the gulf-weed is the Nudibranch *Scyllæa pelagica*. On every bunch of the Sargassum which I hooked up, I found specimens of this interesting animal, which is found in the list of British Nudibranchs, but is not figured in the beautiful monograph of Alder and Hancock. Not long since, Scyllæa figured among the Vermes of Linnæus, until Cuvier first placed it in its true position among the Nudibranchiate mollusca. It is a widely-distributed animal, owing to its habit of living on the floating sea-weed, to which it adheres with great tenacity, by means of the foot or crawling surface, which is said, by most authors, to be deeply grooved, with the two sides extremely thin and flexible, and formed for clasping the stems of the weed—a very necessary provision for an animal living in the open sea, and subject, otherwise, to be washed from its anchorage by every storm, and thus destroyed. Messrs. Alder and Hancock are disposed to believe (arguing by analogy, from other stem-embracing species) that the foot would be found to be really flat, but, from observation, I am able to say that the foot of Scyllæa is not, like other Nudibranchs, absolutely flat when walking upon glass, a small portion only of the foot is flattened out in the centre, like a disc, the remainder of the organ presenting its natural folded appearance. So tightly does it attach itself, that some older naturalists believed that it was per-

manently fixed to the stems on which it lives. The Scyllæa is an active little animal, of a light brown colour, and opalescent, very much compressed, provided with two club-shaped tentacles near the head; and on each side of the back there are two pairs of erect, flattened, irregular lobes, in the inner side of which, and on the back, are the branchiæ, forming delicate tree-like tufts, irregularly scattered. This little creature was in constant motion, contracting itself and writhing about. It readily detached itself from the weed, and swam freely about in the water, moving the head and tail from side to side alternately, so as nearly to touch one another. One very remarkable character was, that when thus swimming, owing to the weight of the tentacles and processes, they turned back downwards, and bore a most grotesque resemblance to a small four-legged animal with long ears—a Scotch terrier, for example. It was in this position that Seba, its first describer, figured it as a young fish; Linnæus, and after him Gmelin, also described it upside down.

The *Scyllæa pelagica* has horny cutting jaws, and is in its way a terrible carnivore; for this alone, of all the Nudibranchiate mollusca, has an armature in the stomach, performing the functions of a gizzard. Its interior is lined with a broad transverse band of dark, horny, lancet-formed plates, having their edges and points sharp, and directed towards the centre of the cavity, which they almost fill. Moreover, the tongue is covered through its entire length with denticulated spines, forming about thirteen transverse rows, divided by a narrow groove down the centre, on which, in each row, is a broad plate, containing a central tooth, with three or four denticulations on each side, the points of the spines being directed backwards and inwards.

I not unfrequently found the spawn of *Scyllæa pelagica,* which has not before been figured. It consisted of a loose straw-coloured coil, entwining the leaves and berries of Sargassum, and imbedded in a mass of transparent gelatinous matter.

Scarcely less numerous than the Scyllæas were the little crabs of the genus Planes (*P. linneana*), belonging to the family of Grapsidæ. These floating crabs abounded on most of the bunches of gulf-weed. The carapace of these crabs is longer than it is wide, and the body is compressed; the tarsi are thick and spinous, and the anterior part of the body projects; the front limbs are short, as are the eye footstalks, the eye occupying half the length. They are confined, like the gulf-weed, to the seas of warm and temperate climates, and offered no particular points of interest, beyond their

numbers, and the proof offered thereby of the plentiful supply of food obtainable by such colonists on the patches of Sargasso. But a more interesting Crustacean is the *Neptunus pelagicus*, or *Lupea pelagica*, so called from his splendid swimming capabilities, which render him like Neptune, the master of the sea. I had been told of a large crab seen swimming by the ship in the open ocean, and shortly afterwards had its existence verified, by taking the above named crab in a towing net in this region. This species swims with great ease and quickness, usually near the surface, and can rest not only upon the drifting seaweed, but even upon the top of the water, remaining suspended motionless at pleasure. Its form is well adapted for speed, the carapace being remarkably flattened, and extremely wide, terminating on either side in a long spine, and having its anterior margin strongly serrated. Its anterior legs are robust and armed with spines, and the chelæ, or claws, are furnished with long sharp pincers, of a singularly trenchant character. It is a very shark among crustacea, swift, certain, and deadly; graceful and tiger-like in its movements, never tiring, or needing the rest which most other swimming animals seem to require. Swimming to a patch of Sargasso it would seem to prey upon its numerous inhabitants, and then swim to another, which in turn it depopulates—a very scourge of these floating colonies. The oceanic swimming crab has a wide range in warm seas, as might have been anticipated from its habits. It is common around India, Australia, and the Phillipine Islands, and is a member of the family Portunidæ.

Among the fishes found in the gulf-weed, the most interesting was a small species of Antennarius, one of the family of the Lophiadæ, fishes of the hard-finned order, generally distinguished by the bones of the carpus being elongated, and forming a kind of arm, which supports the pectoral fins. This little fish lived several days in a globe of water, always remaining among the weed with which it was supplied, and to which it clung tenaciously by its curious arm-like fins. Its movements, owing to this remarkable conformation, were very singular and grotesque, as it seemed to use its fins as though they were hands, and irresistibly gave one the impression of a greater amount of sharpness and acumen than is usually possessed by fishes. It was fed regularly with little bits of meat, which it watched with great circumspection, and would never be induced to leave its hold upon the weed and seize the food, until all appearance of danger had been removed. It is very remarkable how animals which are supplied with any organ which

assimilates them in ever so slight a degree to the human form or habit, acquire thereby, a greater appearance of intelligence; and the fact of this faint resemblance between the pectorals of the Antennarius and the human hand, gave the fish an advantage over its finny brethren which was at once observable. The exigencies of its structure demand a grotesque similarity of function, which is at once striking and interesting.

It is a circumstance well worthy of remark, that all the animals I found harbouring in the Sargasso weed were of the same general tint as the weed itself, assimilating themselves so closely, indeed, in colour, that it was often difficult, at once, to distinguish them. The gulf-weed is usually (as has been observed) of a rich lightish brown colour, with certain parts, as the stems, of a darker brown. The most numerous animals, the Scyllæas, were also of a general light brown tint, and the crabs (*Planes linneana*), although prettily marked, were all a light brown, so that when they got into a mass of sea-weed, it was no easy matter to find them again. Various little shrimps were also of the same colour, and the Antennarius, although exquisitely marked and mottled, blended in tint beautifully with the weed in which it resided. Even the *Neptunus pelagicus*, though usually described as greyish-green, with yellow spots, was here of a clouded reddish-brown tint, little differing from that of the Sargasso. The object of such assimilation one cannot imagine to be otherwise than protection—for although the enemy was equally protected, its prey received the benefit of concealment from it, as it did in its turn from larger enemies, to which it was doubtless amenable; while in its relation to the small creatures on which it fed, its size and activity would be sufficient to counterbalance any advantage they would lose from the concealing colour of their enemy.

I met with a curious instance of prevailing tint also in the Indian Ocean, where the sea had an intensely deep blue colour, of which every animal captured partook. Not only were the Janthinas of their characteristic violet colour, but there were small violet crabs; rich blue Physaliæ with violet threads; blue tinted Velellæ; little violet shrimps; and beautiful crystalline Crustacea (*Phyllosoma*, *Squillericthys*, etc.) almost transparent, but all more or less tinged with violet. As it was impossible to see these animals in the sea from above, so, doubtless, their colour must be a great concealment from their enemies, in an ocean where this colour prevails.

There can be no doubt that the presence of the Sargasso Sea,

by affording harbour and pasture for these animals, even the least of them, owing to their abundance, must have an important influence upon the Fauna of the Atlantic Ocean. For so inextricably are the fortunes and lives of races of animals bound up with one another in the struggle for existence, that this vast feeding ground must offer great supplies of food to predaceous fish, which do not need the protection it affords. We are informed that the pilchards have left the Cornish bays, where they formerly abounded, on account of the sea-weed being cut from the rocks for manuring purposes,—thus destroying the small Crustacea which formed the intermediate feeders between the sea-weeds and the fish. And so we may imagine that in the event of any change in the elements of the Gulf Stream which should materially diminish or alter the position of the Sargasso Sea, the effects would be felt throughout the great fish population of the Atlantic, in widening circles which would probably not leave unscathed the vast banks of cod and herring which so largely supply our markets with wholesome food.

Explanation of Plate.

A. Berry of Sargassum, encrusted with *Membranipora*.
B. Same magnified 24 diam.
C. Ninety-diam., showing form of cells.
D. Circumference of berry, with the Polyzoa in various positions.
E. A Polyzoon of *Membranipora*, magnified 55 diam.
F. Sargassum, with *Campanularia*.
G. *Campanularia*, magnified 90 diam.
H. Sargassum berry, with *Spirorbis*.
I. Ditto, magn.
K. *Spirorbis* expanded, 24 diam.
L. *Scyllæa pelagica* (nat. size).
M. Attitude of ditto, assumed in sinking through the water.
N. Tentacle of *Scyllæa*.
O. Dorsal appendage of ditto.
P. Form of foot of *Scyllæa* when crawling on a flat surface.
Q. Spawn of *Scyllæa* coiled on Sargassum stalk.

THE ORIGIN OF CIVILIZATION.*

Sir John Lubbock's "Origin of Civilization" is a very interesting and readable work, but it is impossible to peruse it without coming to the conclusion that he would have produced a much better one if he had not founded it upon a set of popular lectures delivered at the Royal Institution two years ago. The requirements of a miscellaneous audience, many of them totally ignorant of the subject, and not easily amused without their customary allowance of electric light, magic-lantern work, and brilliant display, could only be met by a very frequent and considerable sacrifice of the subject, and by a treatment rather verging on the flimsy than penetrating into the profound. In spite of the difficulties created by these circumstances, and by the multitudinous labours and engagements of its undoubtedly able author, the book is well worth having as a useful summary of information; and if its arguments are cautiously scanned it will give an important impulse in this country to a study that has many difficulties to contend with, arising from prejudice and old established ideas.

Unfortunately we are not able to trace the progress of any race or nation from the rudest beginnings to the stage we call civilization; and when we contemplate the lives of the lowest savages, we see no tendencies towards a higher development, and in some cases very little capacity for it can be discerned. Thus we are without a satisfactory basis of history for our research; and when our travellers come into contact with savages, they have great difficulty in appreciating their mental states. Sir John Lubbock alludes to the unwillingness of savages to contradict what is said to them, as a frequent source of error, and he cites a story told by Mr. Oldfield of his asking an Australian, who brought him a specimen of Eucalyptus, whether it was a "tall tree," to which he answered in the affirmative; he was then asked if it was a "low bush," and again the reply was "yes." As tall trees pass through stages of growth, the native might have meant that the Eucalyptus in question was found both tall and as a low bush. If this particular Australian was somewhat confused about the relative tallness of trees, are not civilized authors as much so when they describe vaguely as "savages" all sorts of races varying greatly in development. Mr. Dalton, cited by Sir John, speaks of wild men in the

* "The Origin of Civilization and the Primitive Condition of Man. Mental and Social Condition of Savages." By Sir John Lubbock, Bart., M.P., F.R.S., author of "Prehistoric Times," etc., etc. Longmans.

interior of Borneo, "who neither eat rice nor salt, do not associate with each other, but rove about the woods like wild beasts," and are so regarded by the other Dyaks. Among such persons it would be vain to look for more than a mere possibility of culture above the beasts they imitate.

Contrasting with the wild Borneans, whose ideas must be extremely limited, we may place the natives of Tahiti, believing that "not only all animals, but trees, fruit, and even stones, have souls, which at death, or upon being consumed or broken, ascend to the Divinity, with whom they first mix, and afterwards pass into the mansion allotted to each." Here we have a people arriving at a conception of a general law, and exhibiting in a rude form the doctrine of the conservation of force.

Sir John Lubbock adduces many interesting cases of curious customs prevailing amongst widely-separated tribes or races, and we think he is quite right in considering that similar ideas and practices may spring up under analogous circumstances without any communication between the people who adopt them. Probably many human actions have the character which in animals we term "instinctive"—that is, of necessarily resulting from the influence of circumstances on physical organization. In his remarks on the marriage customs of savages, Sir John is disposed to believe that marriage was first communal "when every man and woman in a small community were regarded as equally married to one another," and then became changed into individual marriage founded on capture. Marriage by capturing and acquiring a sort of hunter's or warrior's property in the woman caught, is shown to have had a wide prevalence by recent writers, but there does not seem sufficient ground for recognizing its universality, or for attributing that quality to the so-called "communal" arrangement. Many of the customs of savages in relation to marriage are so disgustingly cruel that they scarcely admit description, and in the book before us is a print representing an "Australian marriage," which consists in the would-be husband, assisted by his companions, dragging away the unfortunate woman, and belabouring her with clubs and wooden swords until she is covered with wounds and blood. Are there any wild beasts who treat their females so badly? Is there not in such cases a degradation from a previous state at least as good as that of tigers and wolves?

The peculiar position of the sexes amongst many savage races very naturally gives rise to the practice of tracing relationship on the mother's side only, the uncertainty of the paternity causing the

father to be omitted from the calculation, and amongst the Tamils of India "a man's brother's children are reckoned as his children, but his sister's children are his nephews and nieces, while a woman's brother's children are her nephews and nieces, and her sister's children are her children." From tracing all relationship through the mother, to a practice diametrically opposite, is a strange contrast, if not transition; and Sir J. Lubbock observes "how completely the idea of relationship through the father, when once recognized, might replace that through the mother, we may see in the very curious trial of Orestes. Agamemnon having been murdered by his wife, Clytemnestra, was avenged by their son Orestes, who killed his mother for the murder of his father. For this act he was prosecuted before the tribunal of the gods by the Erynnyes, whose function it was to punish those who shed the blood of relatives. In his defence, Orestes asks them why they did not punish Clytemnestra for the murder of Agamemnon; and when they reply that marriage does not constitute blood relationship—'she has not the kindred of the man she slew,' he pleads that by the same rule they cannot touch *him*, because a man is a relation to his father but not to his mother."

This view, which appears to us so unnatural, was supported by Apollo and Minerva, and being adopted by the majority of the gods led to the acquittal of Orestes. Sir John thinks that "at first a child was considered as related to his tribe generally; secondly, to his mother, and not to his father; thirdly, to his father, and not to his mother; and lastly, and lastly only, that he is related to both." The foundation of this view is the opinion that in the "primitive" marriage the woman was the wife of the tribe, and that matrimonial pairing was a later invention. Of this we do not see adequate proof, though the wide prevalence of marriage by capture must be conceded. When parents acquired the notion that their daughters were property, wives would be obtainable by purchase, or by robbery, and it is no wonder that the latter was thought an excellent plan.

We do not think Sir John Lubbock treats the question of the moral and religious sentiments and opinions of savages with sufficient caution, nor should we be disposed to accept without considerable reservation and modification his "stages" of religious thought, which are as follows:—"*Atheism;* understanding by this term not a denial of the existence of a deity, but an absence of any definite ideas on the subject: *Fetichism;* the stage in which man supposes he can force the deity to comply with his desires: *Nature Worship,* or *Totemism,* in which natural objects—trees, lakes, stones, animals, etc.—are worshipped: *Shamanism;* in which the superior deities

are far more powerful than men, and of a different nature, their place of abode is also far away, and accessible only to Shamans: *Idolatry*, or *Anthropomorphism*; in which the gods took still more completely the form of men, being, however, more powerful. They are still amenable to persuasion; they are a part of nature and not creators; they are represented by images or idols. In the next stage the deity is regarded as the author, not merely a part, of nature; he becomes for the first time a really supernatural being. The last stage to which I will refer is that in which morality is associated with religion." Scarcely one of these "stages" is free from objection. Let us take the first, *Atheism*, and we ask, why should vagueness (absence of definitiveness, as the author explains) be sufficient to justify the use of this term? In tracing growth we must pay due attention to embryonic forms, and if any "vague notions" can be discovered that can make a step towards Theism, we should not use the term Atheism in such a case. Again, Fetichism is by no means the only stage of religious thought in which man supposes he can force the deity to comply with his desires. Men who take low views of the highest religions are not free from this error, and suppose that by rites, ceremonies, and penances, they can exercise a constraining power.

Sir John's "Shamanism" is scarcely more satisfactory. It may be doubted whether any savage race ever believed in deities quite of a different nature from themselves, and Anthropomorphism meets us at every step when we investigate modern varieties of faith. Accessibility only to "Shamans" is not peculiar to the religion of savages, for in a great variety of the religions of civilized men, we find the intervention of a particular class of persons deemed essential to the propitiation of supernal powers. If the Egyptians and the Hindoos are to be reckoned amongst idolaters, there is much to be found in their belief that will not fit Sir John's definition. Isis, Osiris, Vishnu, and Siva, are not mere parts of nature, or specially amenable to persuasion, and with regard to nature worship, we must not forget the difference between worshipping a particular object as a symbol, or as an actual deity, and the worship of natural powers—generation, etc.—which existed amongst nations who had made great progress in metaphysical thought. The idolatry of a savage is no doubt enormously lower than that of a learned Brahmin or an Egyptian priest, but wherever idols are employed as objects of adoration, the many will, in fact, be genuine idolaters, though the few may regard the images from a purely symbolical point of view.

What a civilized man accustomed to hard thinking calls "reli-

gion," is a highly complex compound of opinions and sentiments, and if we seek to find the earliest roots of such religion in the most barbarous and undeveloped races, we should only expect very simple germs. No creature can think of a deity from whom all things proceed, or by whom all things are fashioned, unless he is able to conceive the idea expressed by "all things." The reference of dissimilar phenomena to one common cause can only take place when considerable powers of generalization and abstraction have been reached. The discovery of savages who have "no idea of a Supreme Being," and "no rites of religious worship," is no proof whatever that germs of religion do not exist amongst them. A savage would not be likely to get at the notion of a Supreme Being until long after he had recognized forces in nature to which he would give names, and more or less distinctly personify. Sir J. Lubbock himself observes, "It seems *a priori* very difficult to suppose that a people so backward as to be unable to count their own fingers should be sufficiently advanced in their intellectual conception as to have any system of belief worthy of the name of a religion." This we can all agree with, but if religion is natural to man, as we contend, we should think it probable that a careful examination of savages who cannot count as far as their fingers, would lead to the detection of some rudimentary capacities which, if developed, would evolve religious thought. If the question were put, "is it natural to man to form general conceptions, and abstract ideas," the reply would be "yes," as soon as the requisite development takes place, and the same answer seems applicable to the inquiry whether religion is natural to man.

In attempts to estimate the religion and morals of savages we must avoid the error of treating as peculiar to them sentiments that with more or less modification may be found in quite different states of society; and when the opinions of a whole tribe or race are described by a traveller, who with imperfect knowledge of their language, has spoken only to a few upon difficult subjects, we may well hesitate to accept any general statement as correct. In our own country, so long the seat of highly-developed religious feelings and ideas, it would be easy to find thousands of persons to whom the whole subject is a blank. When Captain Burton, strangely denominated by Sir J. Lubbock, "as one of our keenest observers," says, "The negroes believe in a ghost but not in a spirit; in a present immaterial but not in a future immaterial," the evidence is upon the face of it worth little. It is highly improbable that the negroes in question have any notion of the metaphysical distinction of the

"material" and the "immaterial." Captain Burton's preponderating perceptions of himself and his want of the power of appreciating any character different from his own, make him a bad witness in any but a purely objective matter, while his deplorably bad style of writing indicates an inability to distinguish delicate shades of meaning in words.

M. Du Chaillu, speaking of the negro, says, "Ask him where is the spirit of his great-grandfather, he says he does not know: it is done; ask him about the spirit of his father or brother who died yesterday, then he is full of fear and terror: he believes it to be generally near the place where the body has been buried." Although M. Du Chaillu may possess many qualifications superior to those of Captain Burton, we should not select him as the fittest person for an inquiry of this description. Those who believe ghost phenomena, when not imposture, to be entirely subjective, will readily understand why the majority of such alleged appearances should be of human beings recently dead, and who left a strong impression behind them on the memories of the ghost seers. When legendary tales acquire a powerful hold over the imagination, and a story has grown up of a particular sort of appearance, we find that reproduced for just the same reason that the form of a recently deceased person haunts a survivor. The mind is in each case strongly impressed with an image which its excitement invests with objective reality. That savages should not see ghosts of their great grandfathers, and should see, or fancy they see, ghosts of their deceased father or brothers, is easily explained by the fact that if they ever knew the former they may have passed out of their memory, while it has retained the more recent pictures vivid and distinct. It would be absurd, without further inquiry, to assume that when the negro said "it is done," or something equivalent to it, he meant that the great-grandfather's ghost had suffered extinction; and no such negro as Captain Burton describes is at all likely to have pondered over the distinction between "immaterials," "present," and "future."

If Sir John Lubbock should at some future date publish a more elaborate work on this subject, we recommend him to pay more attention to the comparative aspects of his inquiry, and not treat opinions of savages without reference to analogous opinions of more advanced races. When he says, "Some races believe in ghosts of the living as well as of the dead," we cannot forget that many, conspicuous of reputation for scholarship and research, have done the same, and fortified themselves with the text, "whether in the body

or out of the body, I cannot tell." As an illustration of his assertion that when ideas of a soul and future life are more developed, they are "far from taking the direction of our belief," he tells us that "the Caribs and Redskins believe that a man has more than one soul;" and he adds, "to this they are probably led by the pulsation of the heart and arteries, which they regard as evidences of independent life." Sir John is a man of too much real learning not to be perfectly well aware that various schools of philosophers have ascribed a complex soul or spirit to man; and if the Caribs and Redskins have thought the matter out as he supposes, they will have arrived at a conclusion bearing analogy to the distinction now very commonly recognized between organic and mental life. Nothing that he states warrants the conclusion that the "belief in ghosts" entertained by savages *is essentially different* from our notions of a future life. Their "ghosts," he says, "are mortal," but no precise evidence is adduced of the assertion; and then we are told, "even when a higher stage has been gained, the place of departed souls is not a heaven, but merely a better world." What of that? Was the Hades of the Homeric Greeks as good as earth? Did the Hindoos or Mohammedans ever give a picture of heaven that was not, in many respects, worse than modern civilization has made earth for its most fortunate individuals; and do not the great majority of uneducated Roman Catholics and Protestants picture the heaven of their aspiration in a very earthly shape?

Sir John Lubbock traces the worship of stones through many races and many ages, and with a little more pains he might find that all the leading points of superstition or belief amongst savage tribes reappear, with modifications, in more developed conditions of society.

The discussion as to the moral character of savages is very unsatisfactory, and the conclusion that "the lower races of men may be said to be quite deficient in any idea of right, though quite familiar with that of law," seems to have been arrived at without due consideration. It is no peculiarity of savages to have "a moral code which permits them to rob and murder." Civilized man, making a war of conquest, acts upon the same sort of code. As soon as savages live in associated groups, they do not think it right to take all opportunities of robbing and murdering each other, though they may direct attention of that description to outsiders. If at Jenna, "When a town is deprived of its chief, the inhabitants acknowledge no law," and anarchy begins. "The same thing has occurred in Europe, and even in England, when the Crown was temporarily vacant; and if "the Fijees consider offences grave or

light, according to the rank of the offender," so did the Anglo-Saxons, in arranging their schemes of pecuniary compensation, reckon them according to the rank of the person against whom they were committed; and our own law provides at this day much better means of punishing the petty pilferings of the poor than the wholesale swindlings of the rich. If we suppose ideas of morality to have grown with the advance of society, we shall perceive that honesty and other qualities beneficially affecting others would have a very limited range of operation in very early conditions, and would extend in area as improvements took place. A man would be honest to his family, to some extent at least, while he might think it praiseworthy to be successfully dishonest to any other within his reach.

Fidelity to his own tribe might easily consist with gross treachery towards another tribe, and those who praised Ulysses for cunning did not expect him to make an evil use of that property against his wife or his friends. When it helped the destruction of the suitors, it advanced what would be deemed the cause of moral justice; but had it been wrongfully turned to the injury of Penelope, it would have met with no commendation from the old Greeks.

To ascertain and correctly describe the mental and moral condition of rude races, is a task that would be extremely difficult to a skilful observer well acquainted with their language and customs. It is quite beyond the reach of the bold sportsmen, the fearless hunters, and men of physical rather than intellectual qualifications, who constitute the majority of travellers in unexplored regions. We have only to read the ordinary books of men who have courageously fought their way amongst barbarous tribes, treating them pretty much as the wild game they pursue, to see how little reliance can be placed upon what they tell us when they leave the ordinary details of adventure and sport. Sir John Lubbock places all sorts of travellers upon an equality as to evidence of matters difficult to ascertain. We cannot say he has done his best to elucidate his subject, but we hope to see him again entering upon it with more leisure and more thought.

ON POISONS.

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No. IV.

Antimony is a brilliant white metal, with a high metallic lustre; it is flaky, and easily breaks up; under slight pressure, it is so brittle that it can be reduced to a fine powder in an ordinary mortar. It has been obtained in rhombohedral crystals, and many specimens of the metal are covered superficially with arborescent forms, resembling fern fronds. It is largely used in the arts to give hardness to the alloys of which it forms a part. Britannia metal, which is used in making articles for domestic purposes, and type metal, are alloys of antimony: the former contains also brass, tin, bismuth, and lead; the latter simply lead—though the better kinds contain tin as well. Although antimony is a very brittle metal, it seems to lose this property when alloyed with others, giving to the mixtures hardness, as in type metal, and a certain amount of toughness, as in Britannia metal. An alloy of antimony and iron has been made, which is exceedingly hard, but it possesses no commercial value. Antimony is sometimes found native, but its most common ore is the sulphide or sesqui-sulphide, which contains two atoms of the metal and three of sulphur: that is, by weight, twice 122 parts of antimony, and three times 32 parts of sulphur; the atomic weights of antimony and sulphur being respectively 122 and 32.

The metal can be obtained from the sulphide in several ways; but the most simple is to fuse it in a crucible with some iron filings. The sulphur unites with the iron, forming sulphide of iron, and the metallic antimony sinks to the bottom of the crucible. It is not, however, pure; it still contains arsenic, which is a constant impurity of this metal, and iron, with perhaps traces of copper and lead. The method of freeing it from these impurities is too complicated for description here; it can be found on reference to Miller's "Elements of Chemistry."

Antimony was known to the ancients, and was used as a cosmetic. Jezebel is said to have painted her eyes with it; the word used is stimium. Stibium is, however, the name given to it by the ancients, but stimium is also used for it. Antimony was known to the Arabians, and was by them called Atemed, and this is supposed to

be the derivation of its name, though others have been given, one of which is interesting, though highly improbable. It is said, though the story does not rest on good authority, that Basil Valentine, a monk in a Benedictine monastery at Erfurth in Saxony, administered this substance to some of the monks, who died from its effects, and it was hence called Antimoine—hostile to monks. The alchemists made frequent use of antimony in their endeavours to discover an elixir for the prolongation of human life. It was called by them Lupus vorax and Saturnis; it was also called by several other names, amongst which was Alcohol. The Tetragonon of Hippocrates is supposed by some to have been antimony. The sulphide, not the metal, was known to the ancients, and they obtained an impure oxide by roasting it. It seems to have been pretty generally used for painting the eyes, especially by the Moors, who introduced it into Spain.

Chemically, antimony belongs to the same family as arsenic. Nitrogen, phosphorus, arsenic, antimony, and bismuth, all have chemical properties so much resembling one another, that chemists class them in one group, although their physical properties are very different. The atomic weight of arsenic is 75, that of antimony 122, and it is found that antimony and its compounds differ from those of arsenic in the way that one would expect from this difference in their atomic weights. Arsenic is volatilized at a moderate heat, whereas it requires a much higher temperature to convert antimony to the state of vapour. Arsenic oxidizes more readily than antimony: for the former metal, by simple exposure to moist air, becomes partially oxidized, forming the substance known as fly powder; but the latter does not take up oxygen in moist air, it only does so at high temperatures, when it burns brilliantly, forming an oxide which consists chiefly of the higher oxide. Antimony, like arsenic, forms two compounds with oxygen, one in which the proportions are twice 122 parts by weight, or two atoms of antimony, to three times 16 parts, or three atoms of oxygen; and the second, or higher oxide, contains the same weight of the metal to five times 16 parts by weight of oxygen. Arsenious acid, the lower oxide of arsenic, is slightly soluble in water, but the corresponding oxide of antimony is quite insoluble. Arsenic acid dissolves readily, but antimonic acid does not dissolve at all in water. When arsenious acid is heated it speedily vaporizes, but the oxide of antimony is much less easily volatilized. This difference serves, in testing, for a distinction between the two substances.

The chloride of antimony, which corresponds to the lower oxide

commonly called butter of antimony, is a transparent solid, having a crystalline appearance not unlike the compound used as a pomatum, which is made by dissolving a small quantity of wax in olive oil. This chloride is easily decomposed by water, forming an oxychloride, which was formerly called the Powder of Algaroth. The chloride is used in the arts in bronzing gun-barrels. A very important compound of antimony is the artificial sulphide. It is used as a pigment under the name of Antimony Vermilion. It has not, however, the brilliant red colour of the true vermilion, which is a sulphide of mercury. But by far the most interesting to the toxicologist of all the antimony salts is that which is called in the pharmacopœia Tartar Emetic. Its chemical composition is explained by regarding it as hydric tartrate (tartaric acid), in which one atom of hydrogen has been replaced by an atom of potassium, and a second atom of hydrogen by the antimony radical, which is represented by the symbol Sb O—that is, one atom of antimony, the symbol for which is Sb, derived from the latin name stibium, and one atom of oxygen. This body, Sb O, has no separate existence. It cannot be obtained alone; but when hydric tartrate reacts upon antimonic oxide, which it readily dissolves, some of its hydrogen unites with part of the oxygen of the oxide, forming water, and the remainder of the oxygen and the antimony take the place of the hydrogen which the tartrate has lost. Now, this salt of antimony and potassium differs very materially from the other compounds of antimony. It is very soluble in water, whereas the others are insoluble. If the terchloride, which has been already alluded to, or if the penta-chloride, which contains more chlorine, be thrown into water, the water immediately becomes milky, owing to a precipitate of oxychloride being formed; but no such effect is produced by the action of water on tartar emetic.

Tartar emetic is made by boiling the acid tartrate of potash with oxide of antimony: the proportion in which they are mixed is six ounces of the former to five ounces of the latter. After boiling and filtering, the salt crystallizes out on cooling. This substance has been long used in medicine; at one time it was largely employed in fevers and in acute inflammation, sometimes in large, sometimes in small doses, but of late years it has almost entirely ceased to be employed in these diseases. It is a powerful emetic, and when used for this purpose it is given in doses of from about two to three grains. Externally it is very efficient as a counter-irritant, and is employed in the form of an ointment or in solution in water. But in large doses it is an irritant poison, and its effects, as such, we have

now to consider especially. Cases of poisoning by antimony are of rare occurrence. The quantity required to cause death is in most instances considerable; this is no doubt owing to its producing vomiting almost immediately after it has been swallowed. Professor Forget, of Strasburg, mentions the case of a strong man, suffering from acute rheumatism, who took a dose of seventy-two grains after commencing with smaller doses, and in ten days he took as much as three drachms in water. Beck relates a case of a child who was killed by taking fifteen grains of tartar emetic, and cases are recorded where two grains in an adult, and three quarters of a grain in a child, have caused death. Death has also followed its external application. An infant, two years old, died in forty-eight hours after its spine had been rubbed with the ointment of tartar emetic. Very serious effects have been produced by moderate doses of this poison. A case is quoted by Dr. Christison, from the "Bulletin des Sciénces Medicales," of a woman who took six grains wrapped up in paper. She was seized with vomiting in half-an-hour, which soon became bloody. In two hours the decoction of cinchona was administered with good effect, but she had severe colic, diarrhœa, pain in the stomach, and some fever. She was not cured for five days. When antimony is used by the poisoner it is generally administered in small and frequent doses. Of late years it has been employed in this way. It is supposed by many that it was with antimony, not with strychnine, that Palmer poisoned his victim. The cases of Dove, Smethurst, and MacMullen have also rendered the consideration of antimony, as a poison, interesting and important.

The first effect produced by tartar emetic is that of sickness: if all the substance be got rid of, no great inconvenience is felt. Its taste is extremely unpleasant, being metallic, or, as it is termed, styptic. It affects the throat and mouth, rendering them sore, producing a feeling of tightness; there is a burning pain about the pit of the stomach; sometimes this pain extends over the whole abdomen, and is accompanied by purging and colic pains. Cramps also are tolerably constant symptoms. There may be tetanic spasms and delirium; and death may occur in the state of collapse. Sometimes its effects resembles cholera. "An apothecary sold tartar emetic by mistake for cream of tartar; the quantity taken was about a scruple (twenty grains). A few moments afterwards the patient complained of pain in the stomach, then of a tendency to faint, and at last was seized with violent bilious vomiting. Soon after that he felt colic pains, extending through the whole bowels, and accompanied ere long with profuse and unceasing diarrhœa. The pulse at the same

time was small and contracted, and his strength failed completely; but the symptom which distressed him most was frequent rending cramp in the legs. He remained in this state for about six hours, and then recovered gradually under the use of cinchona and opium, but for some time afterwards he was liable to weakness of digestion."* When tartar emetic produces death, it may occur quickly, in a few hours, or the patient may live several days. This, however, will depend much on the quantity taken. After death the stomach is found to be affected, also the intestines; in some cases the lungs have been congested, and the brain, it is said, has been implicated. Experiments on animals have shown that the blood remains fluid. Tartar emetic is decomposed by many organic substances, such, for instance, as tannin, decoction of cinchona bark, and these render it harmless by forming with the oxide of antimony insoluble compounds; they are, therefore, good antidotes. After promoting vomiting mechanically, or by giving large draughts of water, decoction of bark should be administered—that of yellow bark (chincona flava) is best; or bark in powder may be employed. Tea, which contains tannin, may also be given; the stomach-pump may too be used. When inflammation of the stomach has been obstinate, bleeding has been resorted to. Opium is also recommended. Tartar emetic has been used to detect persons suspected of making free with drinkables which do not belong to them; it has been put into wine and other drinks for this purpose. After what has been said, it will be clear to all that this substance is one which is too dangerous to be trifled with, and that nothing can justify its employment in such a manner.

Chloride of antimony (butter of antimony) has, when taken, caused death. It is extremely corrosive in its action; Dr. Taylor relates cases in which its effects have been very marked. In one case, that of an army surgeon who swallowed two or three ounces for the purpose of committing suicide, there was entire prostration of strength, excruciating griping pain in the bowels. In the course of a few hours reaction took place, the pain subsided, and the pulse rose to 120. The patient desired to sleep, and appeared as if under the influence of a narcotic; he continued in this state, and died in ten hours and a half. From the mouth downwards, the stomach and the part of the intestines joining it were black, as though they had been charred. There was hardly any of the mucous membrane remaining, and the parts were so soft that they could be easily torn with the fingers. The treatment recommended when chloride of antimony has been taken, is the same as that for tartar emetic. The

* Quoted by Christison from "Orfila Toxicol." i. 74.

analysis for antimony is extremely interesting; because, incautiously, tartar emetic may have been given as an emetic, when other poisons have been taken. In treating of arsenic it was mentioned that this substance should not be used for such a purpose, as it must necessarily complicate the analysis. As it may be used, it is especially necessary that the analyist should be careful that he does not mistake small quantities of antimony for arsenic, and that in poisoning by arsenic, where antimony has been administered as a remedy, he should be careful to make a distinct separation between the two substances, if he should find them present. Tartar emetic is usually met with as a white powder. It may be found in crystals; their form is tretrahedral, more often octohedral. These crystals are efflorescent; that is, they slowly part with their water of crystallization and become reduced to a powder, just as do the crystals of common washing soda.

When in a state of powder tartar emetic has sometimes a yellowish colour. It is very readily soluble in water, and in this respect it resembles corrosive sublimate, and differs from arsenious acid. If the powder be treated with caustic soda, no change in its appearance takes place; in this respect it resembles arsenious acid, and differs from corrosive sublimate, which is changed to a yellow colour by soda or potash. If ammonic sulphide be dropped upon it, a deep orange colour is produced, and round the edges a brown tint appears. Arsenious acid is not changed by ammonic sulphide till the ammonia has evaporated, when it assumes a canary yellow colour, and corrosive sublimate is immediately turned black by the action of ammonic sulphide. If then this substance be tested in powder, it is very easy to distinguish it from the two other poisons we have considered. The effects of heat on arsenious acid and corrosive sublimate have been already pointed out.* When tartar emetic is heated it behaves very differently from both these substances: it first crepitates, the crystals crack and fly about; it then chars and becomes black, and if it be heated strongly on charcoal the metal is reduced and a bright globule of metallic antimony is seen glistening in the midst of the heated carbon. The blow-pipe should be used to obtain this result. In solution tartar emetic may be discovered in the following manner. If hydric chloride (hydrochloric acid) be dropped into a solution containing tartar emetic, very slowly, a white precipitate is formed, and this is redissolved on addition of more hydric chloride. If hydric sulphide (sulphuretted hydrogen gas) be now passed into the solution, a rich orange-coloured sulphide is precipi-

* Page 176.

tated. Hydric chloride produces no apparent change in a solution of arsenious acid, nor in one of corrosive sublimate, and hydric sulphide gives a yellow precipitate in the one and eventually a black precipitate in the other. And here it is necessary to be cautious, for, at first, hydric sulphide gives a yellowish orange precipitate with a solution of corrosive sublimate, and it is only when the gas is in excess that the precipitate becomes black. The author has often known inexperienced persons mistake this precipitate by not continuing the passage of the hydric sulphide for a sufficient time through the liquid. The sulphide of antimony is, like that of arsenic, soluble in ammonic sulphide; and by this reaction, should antimony occur mixed with mercury or lead, it can be readily separated from them, for neither of their sulphides is soluble in ammonic sulphide. When antimony occurs with the copper, after their sulphides have been obtained, ammonic sulphide should not be used to dissolve the sulphide of antimony, as it also dissolves to a very appreciable extent the sulphide of copper; in this case the best solvent to be used for the antimonious sulphide is sodic sulphide, which has no solvent effect on cupric sulphide: in fact, it is always better, when we have a mixture of sulphides, to use first sodic sulphide as a solvent; for it dissolves the sulphides of arsenic, antimony, mercury, and of another metal, tin (a metal to be briefly considered in a future article), and leaves those of copper and the other metals undissolved; and then to reprecipitate the dissolved sulphides by means of hydric chloride; and after that, to treat them with ammonic sulphide, which will dissolve all but mercuric sulphide: in this way we get a better and more perfect separation than by any other—at least, a separation into groups generally, though mercury is isolated. We shall now consider the way in which the sulphides of arsenic and antimony can be separated, and the metals distinguished, when present together. It has been stated that arsenious sulphide is soluble in ammonic carbonate;* antimonious sulphide is not so. Again, arsenious sulphide is not soluble in hydric chloride, and antimonious sulphide is. By either or both these methods the two sulphides can be separated. In performing the last reaction it is well to filter the sulphides from the supernatant liquid, and then to treat them with the smallest quantity of hydrochloride which is sufficient to dissolve the antimonious sulphide, then to filter off the undissolved arsenious sulphide, and to the liquid containing the antimonious sulphide to add water; the sulphide will be again precipitated from the solution by the water, and will be recognized by its orange colour. Or if a portion

* Page 18.

of the solution of antimonious sulphide in hydric chloride be boiled till all smell of hydric sulphide has disappeared, and if water then be added, a white precipitate of oxychloride of antimony will be obtained. These reactions are very distinctive, and go very far to prove the presence of antimony. Marsh's test, which has been described in the article on arsenic,* is also applicable to the detection of antimony. Antimony, like arsenic, forms a gaseous compound with hydrogen. If into a Marsh's apparatus a liquid containing antimony be poured, hydric antimonide will issue from the delivery tube; if the gas be ignited, it will burn with a peculiar flame, somewhat like that produced by the combination of hydric arsenide, but still exhibiting sufficient difference from it to enable a practised eye to detect it. If into this flame a piece of cold white porcelain be placed, metallic antimony will be deposited on it in the form of a dense black cloud. In appearance this deposit differs from that of arsenic obtained in the same manner; it is blacker, more dense, less diffused, and where it is thin has a slate rather than a brown tint, which is characteristic of arsenic. The deposit of arsenic obtained in this way from Marsh's apparatus is soluble in a solution of bleaching powder, whereas that of antimony is not. When the delivery tube through which the hydric antimonide is escaping from the Marsh's apparatus is heated in one place, a deposit of metallic antimony will take place in the form of a blackish ring, having a metallic lustre. This ring will be deposited nearer the flame of the lamp with which the tube is heated than is the case with arsenic, and its tint will differ from that of the arsenic deposit, just as the tints of the deposits on porcelain differ. Sometimes the deposit of antimony takes place on both sides of the heating flame, and this is owing to the fact that antimony is less volatile than arsenic. When the delivery tube is detached, and the metallic deposit heated carefully, air being allowed to pass slowly through the tube, it will be found that antimony longer resists the action of atmospheric oxygen than the arsenic: for, in the case of arsenic, the metal soon disappears, and somewhere beyond it, and at some distance from where it was situated, a ring of white crystals of oxide of arsenic (arsenious acid) appears; but it takes some time, and a higher temperature, to oxidize the antimony. When antimony is oxidized in this manner its oxide is always formed close to where the antimony was, because it is but slightly volatile, and the deposited oxide is much more dense and less crystalline than that of arsenious acid, though it resembles it in colour, being white. Suppose the two metals were

* Page 18.

oxidized together in the same tube, arsenious acid, as we know, is soluble in water, but oxide of antimony is not; therefore, if the part of the tube containing the two oxides be cut off and boiled in water, the arsenic will be dissolved and the antimony left, and in this way they can be separated. Perhaps the neatest and best method of separating arsenic and antimony is to place the delivery tube, from which their compounds with hydrogen are escaping from a Marsh's apparatus, in a solution of argentic nitrate (nitrate of silver). It has been seen that hydric arsenide decomposes argentic nitrate,* and that arsenious acid is found in the solution, and metallic silver is precipitated, the arsenic not being sufficiently powerful to unite with the silver. Antimony under the same circumstances does unite with silver, forming argentic antimonide, which is a black insoluble substance; so that when the two gases, hydric arsenide and hydric antimonide, are passed into a solution of argentic nitrate, arsenious acid is formed, which is dissolved, and argentic antimonide, which is precipitated. If now the antimonide be filtered off from the liquid, and be very carefully washed, the antimony can be got from it by boiling it in hydric tartrate (tartaric acid) in an open vessel; it must be stirred frequently so as to bring the antimony in contact with the oxygen of the air by which it is oxidized, and hydric tartrate readily dissolves oxide of antimony. The antimony may be detected in the solution after filtration, by hydric sulphide, which will throw it down as an orange precipitate.

Reinsch's test has been applied to the detection of antimony. It is not very trustworthy in testing for arsenic; it is less so in testing for antimony. Metallic antimony is precipitated from its solutions by metallic copper; the usual colour of the precipitate is violet, though it is often brown and black. It has been proposed to dissolve the antimony off the copper by boiling it in an alkaline solution of potassic permanganate. This process does not give satisfactory results, and is liable to this objection—that it introduces a strange metal into the analysis, which has to be got rid of directly afterwards. The antimony can be slowly dissolved off copper by boiling it in a solution of caustic soda, or potash; the air oxidizes the natimony, thus rendering it soluble in the alkali, but if arsenic were present it would be dissolved also: this process, therefore, is not a means of separating the two metals. The method of detecting antimony and of separating it from other metals, especially from arsenic, has been dwelt on at some length, because it may possibly be present in a substance to be analyzed, it having been administered

* Page 18.

as a remedy. No great reliance should be placed on the colours of sulphides in performing an analysis, as they often vary very much from their normal colour, and in toxicological investigations they are often masked by the presence of other substances. Nothing should satisfy the analyst but the obtaining all the reactions known, which can be obtained with the poisons suspected to be present; for when so important and serious an issue as the life of a fellow-creature often hangs upon the accuracy of his determination, he must be satisfied with nothing short of *absolute* proof. A case has occurred during the last few years in which those unaccustomed to the difficult task of analysis have, from the colour of a precipitate and a few reactions, pronounced with confidence on the presence of a poison, which it was eventually proved had not been administered. The chloride or butter of antimony, which has on several occasions produced poisonous effects, is, when pure, a white crystalline solid; it is, however, generally met with as a yellow liquid. The reactions already described serve to detect it. In one important respect, however, it differs from tartar emetic when brought into contact with water—it does not mix with it, but is decomposed, a white precipitate being formed. When in solution, this will serve to distinguish it from tartar emetic.

LEAD is perhaps the most important of all the metals whose salts are poisonous, because it is one so much used in the arts, in commerce, and in the business of common life. For years past the water we drink has been stored in leaden cisterns, and has been conveyed by leaden pipes. Beer and other potable liquors, from the manner in which they have been made, and from the way in which they have been served out for use, have been brought into contact with lead, and have been the cause of serious mischief, sometimes ending in death. For the decorations of our houses, for the enamelling of jewellery and metal ornaments, for the manufacture of glass, for the glazing of cards, for the storing of tea, snuff, and other articles of food and luxury, which require to be kept from the action of the air, and for other purposes too numerous to mention, lead is held in requisition. So useful a metal is lead, that in treating of its deleterious effects on the human frame, one can hardly recount the injuries it inflicts on us, without showing how far they are outnumbered by the benefits which it confers; and that with but moderate care the former may be almost entirely avoided. As a poison, lead has been rarely used by the murderer or the suicide, for its action is slow, and cases of acute poisoning by salts of this metal are rare. The most serious effects produced by it are those which

follow its gradual introduction into the system, by whatever cause this may be brought about. The metal lead is not a poison, but from the readiness with which it is acted upon by moisture in the presence of air, and by acid liquids, it soon forms compounds which are very injurious in small quantities, and which become fatal in their action when, by accumulation, those small quantities become large ones. The appearance which lead presents is so familiar to all, that it is needless to describe it. The metal is so soft that it can be rolled into sheets with comparative ease or drawn into wire; but it is wanting in tenacity, it will not bear a strain. Unlike most other metals, when lead is expanded by heat, it does not contract, on cooling, to its original size; this is seen in lead roofing which is exposed to the sun's rays, and in sinks which are exposed to changes of temperature, from the hot and cold water which is poured into them, for the lead buckles, as it is termed, and folds or creases interrupt its even surface.

The most common ore of lead is the sulphide; it is called galena; and from this the metal is usually extracted by a very interesting process. The sulphide is roasted in a closed furnace, to which air can be admitted. The oxygen of the air removes part of the sulphur from the sulphide, forming sulphurous acid (a gas well known, by its unpleasant smell and irritating effects on the mucous membrane, to travellers on the Metropolitan Railway), and the lead thus freed from sulphur takes oxygen in its place, and becomes plumbic oxide. Plumbic sulphate is also formed by the oxidation of another portion of the sulphide. When this operation has continued for some time, air is excluded from the furnace, and now the oxygen of the plumbic oxide and of the sulphate acts upon the undecomposed sulphide, taking from it its sulphur, and the sulphur of the sulphate, with its remaining oxygen, leaves the lead; and thus in both cases the lead remains as metal, whereas the other elements, sulphur and oxygen, escape as sulphurous acid. The silver, which is present in small quantities, is removed by a process called, after its inventor, Pattinson's process, and about 300 ounces of silver are, by it, obtained from a ton of lead. The salts of lead most commonly met with, and which have been known to produce poisonous effects, are: the oxide, or litharge, red lead; the acetate, or sugar of lead; and the carbonate, or white lead; the nitrate, sulphate, and chloride are also used in the arts. The characters and composition of these salts will be considered with the analysis for lead.

For a long time past it has been the custom to store water in lead cisterns, and to conduct it through lead pipes; but of late years, slate

and other less objectionable materials have come into use for cisterns, and gutta percha has been used for pipes; but where lead is still employed, the pipes are generally coated inside with tin. The use of lead for such purposes is most objectionable, as will be seen from what follows:—If a bright sheet of lead be exposed to the air, it gradually becomes dull or tarnished; the presence of moisture is, however, necessary to produce this effect. The dulness is owing to the formation of oxide on the surface of the lead; and, if the lead be in contact with water, this oxide is dissolved. The carbonic acid of the air, acting on the plumbic oxide, forms a kind of carbonate, which chemists call a basic carbonate—that is, in the same compound with the carbonate there is also a certain quantity of the hydrated oxide, or hydrate of lead. This carbonate is very nearly insoluble, and as it leaves the surface of the lead a new surface is exposed to oxidation, and thus the metal gradually becomes converted into salts of lead, which find their way into the water. These changes take place more largely and with greater rapidity, according as the water is pure or impure. *Pure* water has the most rapid solvent action on lead. The presence of certain salts in water prevent its entering into solution. Calcic hydro-carbonate (the salt of lime which usually exists in spring water) has a marked effect in keeping it free from lead when it is in contact with that metal, for the lead becomes coated with plumbic carbonate, which is insoluble, and so its surface is protected from further corrosion—it seems to act as a coat of paint. Organic matter, whether vegetable or animal, which is found in such large quantities in rivers and ponds, when it is decomposed, gives rise, by the oxidation of its nitrogen, to the formation of nitrates and nitrites. These compounds act upon lead, and cause it to enter into solution. Chlorides also act in a similar manner. Lead may be kept without tarnishing in water that has been boiled, as, by boiling, the air has been excluded, and without oxygen the lead cannot become oxidized. There is no doubt that, with constant attention, water might be kept in leaden cisterns without taking up sufficient quantity of lead to be injurious. In fact, we know that for the quantity of leaden cisterns used, the cases of injury from lead taken in ordinary drinking water are rare, and for this we have to thank the impurity of the water with which we are supplied. But many cases have occurred of impaired health which have been clearly traced to the water which the sufferers have drank; and who knows but that many of the ailments which trouble us—such, for instance, as impaired digestion—may not be aggravated, or even caused, by taking lead frequently, although in very small quantities; for it must

be remembered that it is a substance which accumulates in the system, and only makes its presence known after it has established itself in force so considerable that its attacks are violent and often fatal, and that it can only be removed with difficulty, when detected. It is to be hoped that in time lead cisterns and pipes will altogether give place to others made of materials which cannot in any way prove injurious.

So long ago as the time of Augustus it was well known that water in contact with lead was liable to contain salts of that metal; and, as a consequence, the Roman architect, Vitruvius, prohibited its use in the construction of pipes for conducting water. Galen discountenanced lead vessels for storing water, as well as lead pipes. He knew the properties of the metal, and that water containing lead affected the persons who drank it with dysentery. A family in the town of Worcester was subject to constant attacks in the stomach and bowels; eight of the children and both the parents died in consequence. The house being sold after their death, the purchaser found it necessary to repair the pump, because the cylinder and cistern were riddled with holes as thin as a sieve. The plumber who renewed it informed Dr. Wall, who relates the story, that he had repaired it several times before, and in particular had done so not four years before the former occupant died.*

At Tunbridge in 1814 leaden pipes were used for conducting water; there were, after a few months, many cases of what is termed lead colic; one person who drank largely of water lost the use of her limbs for a time. Iron pipes were used to replace the lead ones, and immediately the colic disappeared. The water was analyzed by Mr. Brande, who found that it contained lead. Dr. Christison, who has carefully examined this subject, and from whose treatise on poisons the above cases are taken, expresses his conviction, after experiment, that the water supplied at Tunbridge could not pass through lead pipes or be stored in lead cisterns without becoming impregnated with lead. He also mentions another interesting case of a gentleman in Dumfriesshire, who resolved to bring to his house in leaden pipes the water of a fine spring on his estate, from a distance of three-quarters of a mile. He says, as I happened to visit him at the time, I took the opportunity of examining the action of a tumbler of the water on fresh-cut lead, and could not remark any perceptible effect in fourteen days. It appeared to me, therefore, that the water might be safely conveyed in lead pipes, and they were accordingly laid. No sooner, however, did the water come into use in the

* Trans. of London College of Physicians, ii., 400.

family, than it was observed to present a general white haze, and the glass decanters in daily use acquired a manifest white, pearly incrustation. On examining the cistern, the surface of the water, as well as that of the cistern itself, where it was in contact with it, was found completely white, as if coated with paint; and the water taken from the pipe, though transparent at first, became hazy and white when heated or left some hours exposed to the air. On afterwards analyzing the water direct from the spring, I found it of very unusual purity, as it contained scarcely a 20,000th of solid ingredients, which were sulphates, chlorides, and carbonates. It is easy to perceive why the experiment with a few strips of lead in a tumbler was not a correct representation of what was subsequently to go on in the pipes; in fact, as the pipes were four thousand feet long, and three-fourths of an inch in diameter, each portion of water may be considered as passing successively over no less than 784 square feet of lead before being discharged It will be seen from this case that although a chemist of great practical experience considered it safe to use lead pipes, judging from his experiments, yet, by the more perfect contact with the lead, the water was rendered unfit for use owing to its impregnation with the lead. The practice of using lead pipes for beer engines is most reprehensible, unless they are protected by some metal not acted upon by the acids of beer. Formerly serious accidents occurred before the discovery of a method for easily and cheaply lining lead pipes with tin. The beer which remained in the pipes all night, dissolved sometimes a considerable quantity of lead, and those who applied for drink in the early morning often suffered very severely from this noxious substance. Although lead pipes are now, when used for this purpose, always tinned inside, yet it is advisable to throw away the first portion of beer drawn, as the tin lining, which is very thin, may be, from age or other circumstances, imperfect in places. Vegetable acids attack lead as they do copper; they should not, therefore, be allowed to come in contact with it, if they are to be used in any way as articles of food. Fats, also, exert a solvent action on lead, and this should be borne in mind; for although they are not as often exposed to its influences as they are to copper in domestic operations, yet there are occasions in which lead, and compounds of lead, are used in domestic utensils.

Pewter contains lead, and so do some of the glazes used to coat earthenware vessels, for the soft glazes used in pottery ware contain plumbic oxide. Dr. Beck relates the case of a family in Massachusetts, consisting of eight persons, who were attacked with colic, costiveness and vomiting, and the disease was satisfactorily traced to a store of

stewed apples, which had been kept some months in an earthenware vessel and had corroded the lead glazing.*

Another case is related by Dr. Hohnbaum, of Hildburghausen, of a family of five persons, who were attacked with colic and palsy. In this case it was found that the vinegar for salad dressing was kept in a large earthenware vessel glazed with lead; and that, on analysis, one ounce of the vinegar contained nine grains of lead, and that the whole glazing of the vessel was completely dissolved. There is no doubt that if much oxide of lead is used in a glaze, it will be, in part at least, dissolved by the action of vegetable acids.

Snuff is generally preserved in lead to keep it moist; now the acids in the snuff, formed by the fermentation of the tobacco, act on the lead, so that the portion of snuff in contact with the lead gets impregnated with it. Snuff-takers should bear this in mind, as, on analysis, it has been found that very appreciable quantities of lead are contained in some kinds of snuff. Shot is used in cleansing bottles, great care should be taken to have them well cleansed after the shot has been used. Cider, wine, and beer should not be allowed to stand in pewter or leaden vessels, for they will most certainly become contaminated with lead.

Milk, by standing in leaden vessels, has become poisonous. A case is recorded by Dr. Darwin of a farmer's daughter, who used to wipe the cream off the edge of the milk, which was kept in leaden cisterns, and being fond of cream licked it from her fingers. She was seized with symptoms of lead colic, afterwards with paralytic weakness of the hands, and she died of general exhaustion.

Some lead salts are employed in medicine. The oxide is used for making lead plaster; the iodide, which is also used externally in ointment or plaster, is seldom given internally; the acetate is used internally, it has an astringent and sedative action, and is given in hæmorrhage, and in diarrhœa and dysentery; the subacetate, known commonly as Goulard's wash, is only used externally as a lotion; and the carbonate, which is only employed externally. The carbonate of lead is used very largely in the arts, especially by painters; it forms the white paint of the house painter. The manufacture of carbonate of lead is very interesting; it is formed by a chemical process somewhat similar to that which takes place when lead is acted upon by water. Thin strips of lead are coiled up and placed, not in water, but in vinegar, the vinegar is contained in earthen pots, and does not entirely cover the lead; thin sheets of cast lead are used for this process, rolled lead does not answer as well; the

* "Elements of Medical Jurisprudence," ii. 319.

pots are placed in rows and covered with boards, and are imbedded in spent tan or cow-dung. The rows are stacked one upon another, and the stacks often rise to a considerable height. The heat generated by the decomposing tan or cow-dung causes the vinegar to vaporize; this and the oxygen of the air acting on the lead forms plumbic oxide, which unites with the acid of the vinegar, forming a basic acetate of lead.

Carbonic acid is generated by the oxidation of the carbon of the tan or cow-dung, and this combines with the lead salt, forming plumbic carbonate and plumbic acetate. This acetate acts on more plumbic oxide, and basic acetate is again produced. The process continues till most of the lead is thus converted into carbonate. The carbonate formed is very hard, and retains the shape of the coiled metallic lead. It is ground by machinery with linseed oil, and in this way what is commonly called white lead is made. Sometimes it is ground with water, and then it is obtained, when dry, as a white powder. Carbonate of lead, when mixed with oil, saponifies to a certain extent, and is so rendered useful to the painter, for it gives what is called *body* to paints made with it. White lead is very generally adulterated with sulphate of baryta. White lead is also used for enamelling cards, to give them that glossy appearance so well known on the surface of visiting cards. From constantly handling carbonate of lead, painters and card-enamellers are subject to a disease called painters' colic, which will be described when treating of the symptoms of lead poisoning.

Pure white lead dissolves completely in hydric nitrate; but if it is adulterated with sulphate of baryta, a white residue will remain undissolved, for that substance is not soluble in acid liquids. Acetate, or sugar of lead, has been more frequently taken as a poison than any other salt of lead. It is not much used in the arts, but is more largely employed in those hair washes which, it is said by their manufacturers, do not act as dyes, but by nourishing the roots of the hair, restore it to its natural colour after it has become white. These hair washes consist of sugar of lead, glycerine, and powdered sulphur, and certainly have the effect of changing the colour of white hair to a sort of brown. That they act as their makers state is very unlikely, and experiments which the author has lately made go to prove that they are, in every sense of the word, dyes. The lead becomes gradually converted into sulphide, and this, when in small quantities, has a brown tint; but in large quantities is black, or nearly so. The hair, no doubt, absorbs the wash, and the lead salt becomes decomposed in the structure of the hair tubes, just as dyes

do in the fibres of cloth or cotton, and so remains fast—*i.e.*, the colour cannot be removed by washing. Whether it is dangerous to use these washes has yet to be proved. A person suffering from a swelled joint is often told by his medical adviser to use Goulard's wash frequently, and it is not known that bad consequences result from its absorption; it therefore seems unlikely that injurious effects would be produced by the application of a similar substance to the head, especially when this is to be soon converted into an insoluble salt which is much less likely to be taken into the system. It is said that wines are sometimes treated with sugar of lead to destroy acidity, or to prevent them from turning sour. "At one time home-made British wines must have been frequently adulterated with lead, from the makers being ignorant of the dangerous nature of the adulteration. Sir G. Baker quotes the following receipt in a popular cookery book of his time:—'To hinder wine from turning: Put a pound of melted lead in pure water into your cask, pretty warm, and stop it close."* Cider formerly commonly contained it, owing to the lead used in the vessels in which it was stored or made.

A disease very similar to lead colic used to prevail in the summer-time in some of the cider districts of England; it was supposed to result from excess of cider drinking, but the subject was investigated in 1767 by Sir G. Baker, who found that the cider was impregnated with lead, and that this was sometimes put in on purpose to correct acidity. Lead is now not employed in the cider apparatus. As recently as 1841 it was found that the cider drank in France contained lead, and produced lead colic. Red lead or litharge is generally met with as a dull reddish powder, but sometimes in rather bright scales; this latter form is owing to its partial fusion; it is used in glass making and for imparting drying properties to oils. Boiled linseed oil is prepared with litharge. Red lead or minium is a mixture, in variable proportions, of the oxides of lead, viz., litharge and the binoxide. The binoxide is a brown powder, and can be separated from red lead by the action of hydric nitrate, which does not dissolve it, but which with the red lead forms soluble plumbic nitrate. Red lead is chiefly used as a pigment. When lead salts are taken, they are absorbed, and are found, on analysis, in some of the organs and tissues of the body; they also appear in the excreta; they act as irritants, though less powerfully than arsenic and mercury. The symptoms are pain in the throat, tenderness of the abdomen, colic pains, great thirst, cramps in the

* "Christison on Poisons," Ed. 4, page 539.

limbs, cold sweats, and constipation. When lead is slowly absorbed into the system, as in the case of painters or of those engaged in working in any way with lead, attacks of a disease which has received the name of painters' colic come on. This affection commences with violent pain in the abdomen. The pain seems to be greatest at the navel and about the pit of the stomach; it is invariably relieved by pressure, and, in this, it differs from the pain consequent on inflammation. There is often vomiting, but no fever or increase in the frequency of the pulse beats; on the contrary, they seem rather to diminish in number, and sometimes fall as low as between forty and fifty per minute. The pain about the navel is characteristic, it produces a severe grinding or twisting sensation, and the skin of the abdomen becomes tense. This colic is brought on by other causes than those mentioned. Sleeping in a recently painted room, drinking fluids which have contracted lead from the vessels in which they have been kept, taking snuff adulterated with lead, are causes of this disease. After several attacks persons sometimes suffer from what is called lead palsy. The nerves of the fore-arm become affected, the muscles which extend the hands and fingers are paralyzed, so that the patient loses power over them, and the hand drops—hence the name for the disorder, "wrist-drop." Lead colic frequently accompanies this paralysis, and there is an unmistakable purplish line on the edges of the gums, where they are in contact with the teeth; this blue colour is owing to the formation of lead sulphide, and is peculiarly characteristic of lead poisoning. Besides painters and those who take lead by the mouth, type-founders, glass makers, glazed-card manufacturers, and all workers in lead, often suffer from this disease. Dr. Guy states that he has seen two or three cases of lead poisoning amongst fishmongers, resulting from their handling lead counters covered with brine. Cleanliness is the best preventive of this disease, which sometimes terminates fatally if not checked in time, a species of apoplexy coming on accompanied by giddiness, weakness, and torpor, from which the patient dies convulsed and comatose.

In acute lead poisoning, after death, the large and part of the small intestines are usually found to be inflamed, and the coats of the stomach disintegrated. The blood is sometimes found fluid, sometimes coagulated. The bodies of those who have died of lead colic do not exhibit these appearances; there are no effects of inflammation to be seen; in fact, there are no very constant morbid appearances with the exception of constriction of the intestines, indicating contraction of their muscular coat. The sulphate of lead

is very insoluble, so that soluble sulphates act as antidotes in lead poisoning. Louisa Wallace, age nineteen, was admitted into University College Hospital under the care of Dr. Thomson. An hour before her admission she had taken two pennyworth of sugar of lead for the purpose of poisoning herself; the quantity was supposed to weigh about one ounce. In a quarter of an hour she vomited violently; sulphate of zinc was administered, also dilute sulphuric acid; on the following day she took sulphate of magnesia. The pain in the stomach, which she complained of, was relieved by two leeches, and one grain and a half of opium extract. In a few days she was discharged cured. The vomiting, in the first instance, was caused by the excessive quantity of the acetate taken, it acting as an emetic from its irritant quality. Her cure was doubtless owing to the sulphates given to her. Where no vomiting is induced by the poison, emetics should be given; zinc sulphate is the best, because lead sulphate is formed and zinc acetate, the lead sulphate being harmless and the zinc acetate acting as an emetic. The stomach-pump can also be used with advantage. Dr. Christison mentions the phosphate of soda and alkaline carbonates; these latter seem hardly suitable, as they form carbonate of lead, which is itself a poison, and Dr. A. T. Thomson attributes to it more poisonous properties than to other lead salts, and he considers that the acetate, taken in moderate doses, only becomes poisonous when it is converted into the carbonate. White of egg and milk are very serviceable as antidotes, as lead forms insoluble compounds with albumen. Opium with purgatives is given with good effect in painters' colic and chronic cases of lead poisoning. The detection of lead is not difficult. If the acetate in powder be heated, it melts; if the application of heat be continued, it becomes charred (in this treatment it differs from tartar emetic, which does not melt, but decrepitates). If the heat be continued, a globule of metallic lead is formed by the reducing action of the carbon of the acetate; under similar circumstances a globule of antimony is obtained from tartar emetic, but there are very distinct differences to be observed between the behaviour of it and the tartar emetic: the odour from the tartrate is like that of burnt sugar, that from the acetate is of acetic acid; and, again, if the globule of antimony obtained be struck, it breaks instantly into glistening fragments, whereas the lead is flattened. If the powdered acetate be treated with ammonic sulphide it turns black; so does the carbonate of lead, and in this it resembles corrosive sublimate, and differs from tartar emetic when heated. Plumbic carbonate differs from the acetate in that it, by losing carbonic acid,

it becomes plumbic oxide, which is of a dirty brickdust colour, and which by further heating is fused not reduced to metal. Acetate of lead is very soluble in water; in a solution of a lead salt, hydric sulphide produces a black precipitate if the lead be present in quantity, but brown if there be only a trace of it. In a specimen of water containing a very minute quantity of lead, this gas produces a brown discoloration. Lead sulphide when treated with hydric nitrate is decomposed, lead nitrate being formed and sulphur set free, some of which, being oxidized by the nitrate, forms sulphuric acid, which with lead oxide forms lead sulphate; and as this is a white insoluble powder, a white cloudiness, and eventually a precipitate, almost invariably attends this reaction.

With hydric chloride, soluble lead salts, if they be present in tolerable quantities, give a white crystalline precipitate, soluble on boiling, but which reappears when the liquid cools. Plumbic chloride is only slightly soluble in cold water, hence the precipitate; but, as it is soluble to a certain extent, no precipitate is formed by hydric chloride if only a small quantity of lead salt be present. Potassic iodide throws down a beautiful yellow precipitate from solutions containing lead. When warmed with sufficient water, the iodide of lead dissolves, but on cooling it reappears in beautiful yellow metallic-looking scales. This test is highly characteristic, and when obtained proves absolutely the presence of lead. This reaction may be applied to a dry acetate of lead, just as it is applied to corrosive sublimate.* It will be remembered that with the sublimate a vermilion red colour is obtained, but with the acetate the colour is yellow. Caustic soda precipitates plumbic hydrate from a lead solution, which is dissolved by excess of that reagent. Hydric sulphate also throws down a white precipitate of plumbic sulphate, soluble in ammonic acetate. If in a solution of a lead salt a piece of metallic zinc be placed, the lead is deposited in very beautiful arborescent forms on the zinc; and this method is used to detect lead: even when present in very small quantities these forms may be seen by examining the fragment of zinc under the microscope. Red wafers are coloured with red lead; if one of these be burned—with care—a globule of metallic lead will be obtained. If a powder is supposed to be oxide of lead, or to contain it, if it be heated with charcoal in the reducing flame of the blow-pipe, lead will be obtained; or if it be treated with hydric nitrate the solution will give all the reactions already described. Lead can be separated from the other metals which we have considered: first, from antimony and arsenic

* Page 176.

by the insolubility of its sulphide in ammonic sulphide; from mercury, by the solubility of its sulphide in hydric nitrate; and from copper, by treating a solution containing nitrates of the two metals with hydric sulphate, which precipitates the lead, but leaves the copper in solution.

TYNDALL ON IMAGINATION IN SCIENCE.

One great use of the British Association of Science arises from the opportunities it affords to a few eminent men to ventilate questions that would otherwise find their way very slowly into the mental atmosphere of society. Great thinkers, in all ages and in all countries, have had many ideas in common, but the world has known little about them, either neglecting their opinions, or first misrepresenting and then denouncing them as heretical. A few years ago there was a marked discrepancy between the thoughts freely exhibited in the common intercourse of scientific men in the Metropolis and those which it was prudent to divulge in any social gathering of the ordinary kind; and even now there are circles pretty numerous in great towns, and abundantly traceable in rural districts, where no one would be safe from social persecution who should venture to express a belief in the antiquity of the globe, or the existence of man upon it, before the date which Archbishop Usher and his followers assigned to the creation of Adam, upon what they deemed scriptural grounds. "Society" attempts to decide what its members may think and feel, as well as what they may do, and finds it much more difficult to change the fashion of its mental clothing than to alter the cut of the outward habiliments it wears. Amongst the most daring invaders of old-established quietudes, are Professors Huxley and Tyndall; the one combative by nature, and the other apparently so under compulsion, because he finds prejudice obstinately blockading truth.

At the late gathering of the British Association at Liverpool, Professor Huxley gave his audience a moderately good, or moderately bad, sketch of the spontaneous generation controversy and matters pertaining thereto, arriving at the conclusion, so frequently stated in our pages, that the balance of evidence leads to the belief that all the life we can trace descends from previous life that stood towards it in parental relation. Professor Tyndall tried a more difficult subject; and, if his lecture on "the Scientific Use

of the Imagination" will not in all respects bear strict criticism, it is sure to prove highly valuable in the twofold way of stimulating many to think, and many, who have thought, to communicate their results. An old chieftain, when told by a priest where he was to go if he did not believe as he was commanded, and assured that all his forefathers had gone there before him, replied that he would rather go anywhere with his noble and valiant ancestors than to the best possible place with a parcel of priests and beggars. In fact, under all circumstances, there are men who desire to be in good company, and many will feel able to bear the assaults of bigotry and ignorance in company with Huxley and Tyndall, who might shrink from the ordeal if they had to stand alone.

Professor Tyndall might have treated his subject with a wider grasp and better illustration, both historical and metaphysical; but we must remember his "discourse" took the position of an after-dinner speech, and he had to deal with a subject that could scarcely be considered to promote digestion, and which might seriously disagree with the mental stomachs of many to whom the new (old) truth was offered in the place of wine and dessert. We do not see much wit in describing Goethe's "Theory of Colour"—"Farbenlehre," as the Professor, following the original, prefers to call it—and Mr. Bain's "Logic" as "two volumes of poetry;" nor do we imagine that he read much of either during his Alpine tour. He was, however, much struck with Mr. Bain's saying, "The uncertainty where to look for the next opening of discovery brings the pain of conflict and the debility of indecision;" and also with the statement—commonplace enough—that "present knowledge must forge the links of connection between what has been already achieved and what is now required." This last passage describes a process with which imagination has very little to do, and if "organic germs," "molecules," "light," "heat," "comets," and "skies" have to be united by some band of philosophy, the function of scientific imagination differs widely from that step-by-step process by which actual knowledge forges a link from what it knows towards that which it would add to its store. Shakespeare, in a well-known passage, makes "imagination body forth the forms of things unknown," and tells us how

> "The poet's pen
> Turns them to shapes, and gives to airy nothings
> A local habitation and a name."

In this passage Theseus, in whose mouth it is put, describes "the lunatic, the lover, and the poet" as "of imagination all compact;"

but he discriminates between the operation of the faculty in each one, and it is the poet's variety of the quality and power that is most akin to that which exists in the philosopher, and which the Professor intended to describe. How and why great men of science have imagined connections between things too apparently remote for step-by-step logic to trace any chain between them, is an inquiry in which the difficulty is commensurate with the interest; but the tendency of the philosopher to bind vast multitudes of facts into symmetrical masses of broad generalization, and the striving of the poet after universal truth, are mental operations closely analogous, if not similar, in kind. We doubt, however, if Professor Tyndall is right in saying that, without imagination, "causal relations would disappear," as immediate or proximate causation can be traced without its aid. As to dislodging the "Soul of Force from the Universe," which he describes as another calamity that would result from loss of the imaginative faculty, we are inclined to think that imagination may be somewhat sleepy when she bestows upon Force the soul of which he speaks. The faculty of abstraction is no doubt assisted by the imagination when it conceives of force as a distinct entity, and it is often extremely convenient to speak of "forces" without at any particular time being obliged to conjoin to the idea some notion of matter or substance as its substratum or its essence. Some philosophers imagine *force* to be the only real entity and matter phenomenal; others regard the matter as real, and the force as its property, resulting from some kind of motion. Scarcely any imagination, and but little more than the power to perceive proximate analogy, is necessary for some of the processes which the Professor has selected as his illustrations. Any one who sees a wave produced by throwing a stone in a pond, can conceive that there may be an air-wave as well as a water-wave produced by a shock at a particular point, and, when once wave forces are understood, a very small quantity of imagination will imagine a fluid rare enough for those of light.

It may be, and probably is the fact, that all space through which light passes does contain matter in a form so light and so elastic as to allow wave-force to be propagated through it as sound is propagated through air; but when imagination is exercised upon this subject, its function seems to be that of enabling us to conceive some of the (probable) conditions of the process. Are the ether particles in contact, or what is between them? Does the wave force leap from particle to particle across a microscopical gulf, or does matter possess such expansive powers that

there are no gulfs, and all interspaces are filled up? Professor Tyndall thinks modern chemists deficient in imagination because they hesitate to believe in the "atoms" of Dalton. He says, "Their caution leads them to stop short of the clear, sharp, mechanically intelligible atomic theory enunciated by Dalton, or any form of that theory, and to make the doctrines of multiple proportions their intellectual bourne;" and he goes on to observe that imagination is not satisfied with "a vibratory multiple proportion, or a numerical ratio in a state of oscillation." After reading these passages we must ask, does the Professor understand the matter on which he speaks with such comforting self-assurance? Are all difficulties of chemical or molecular science disposed of by imaginary "atoms," and then taking care to imagine no more? The question of the divisibility of matter is certainly not yet solved, and perhaps never will be solved by mortal minds. The "atom" which many modern chemists do not pin their faith to is explained, so far as relates to its supposed physical characters, with his accustomed clearness, by Dr. Arnott, in his "Elements of Physics," where he tells us "The visible universe is built up of very minute indestructible ATOMS, called matter, which, by mutual attraction, cohere or cling together in masses of various form and magnitude. The atoms are more or less approximated, according to the repulsion of the quantity of heat amongst them," etc., etc. Professor Tyndall has written admirably and eloquently upon heat as a "mode of motion," and he tells us that where there is motion something is moved. If he accepts Dr. Arnott's atoms, which are the orthodox article, either they must touch, or there must be space between them. Dr. Arnott fills these spaces with heat; Dr. Tyndall would, we suppose, put ether into them, and this ether, again, will either have atoms or be atomless: if the former, what lies between them; if the latter, are atoms of the indestructible character described by Dr. Arnott? Modern chemists have reasons for doubting the existence of these atoms, belonging to their special science, and we believe their only defender of eminence is Dr. Williamson, whose ideas seem sufficiently obfuscated by fog atoms not to be worth much as relates to this particular subject. It may require what is called a stretch of imagination, or want of the faculty, to be as satisfied with "atoms" as Professor Tyndall professes to be; but other philosophers employing their imagination, cannot stop at particles of matter so hard or so peculiar that they admit of no division or change.

Professor Tyndall makes an amusing appeal to our imagination when he conjectures that the particles which form the sky might

all be packed into a snuff-box, or, at least, in a portmanteau, but when he quotes Huxley as an authority for the assertion that precipitated particles of mastic which give an imitation of sky colours in water, could not be $\frac{1}{100,000}$ of an inch in diameter, he relies upon what, to say the least of it, is a very imperfect investigation. What is the difference between solution and the suspension of infinitesimal particles, and what proof is there that not one atom—we use the word in its common sense—of the gum is dissolved. Dropping very dilute mastic varnish into water, in the way he describes, does not produce anything fairly called *turbid*. Turbid water is water disturbed by something which makes it muddy—particles which remain in suspension, and give it a tinge of colour, cannot be said to occasion turbidity.

Passing to matters on which we can agree with the learned Professor, we have pleasure in citing his remarks on the distinction between the microscopic and the molecular limit, though he has not stated it quite fully. He says, "When, for example, the contents of a cell are described as perfectly homogeneous, as absolutely structureless, because the microscope fails to distinguish any structure, then I think the microscope begins to play a mischievous part. A little consideration will make it plain to all of you that the microscope can have no place in the real question of germ structure. Distilled water is more perfectly homogeneous than the contents of any possible organic germ. What causes the liquid to cease contracting at 39° Fahr., and to grow bigger until it freezes? It is a structural process of which the microscope can take no note, nor is it likely to do so by any conceivable extension of its powers." As a mere microscope, we apprehend, this is true, though possibly, in conjunction with some other apparatus, it may ultimately give us some account of molecular change.

The defence of Darwin's Pangenesis theory is honest and useful. People do need to be reminded that Nature transcends their expectations, and that when they get amongst them a great mind like Darwin's, "which can never sin wittingly against fact or law, they should respectfully heed what he says, unless they are perfectly sure he is overstepping the bounds of reason." In his case, as Professor Tyndall remarks, "observation, imagination, and reason combined, have run back with wonderful sagacity and success over a certain length of the line of biological succession."

The goal of Professor Tyndall's discourse, which he was aiming at all through, is reached when he gives us his views of the origin of life; and starting with our earth or system in a nebulous form, he

says: "Two views then offer themselves to us—life was present potentially in matter when in the nebulous form, and was unfolded from it by way of natural development; or it is a principle inserted into another at a later date. . . . . The gist of our present inquiry regarding the introduction of life is this: Does it belong to what we call matter, or is it an independent principle, inserted into matter at some sensible epoch—say when the physical conditions became such as to permit of the development of life? . . . . Did creative energy pause until the nebulous matter had been condensed, until the earth had become detached, until the solar fire had so far withdrawn from the earth's vicinity as to permit a crust to gather round the planet? Did it wait until the air was isolated, until the seas were formed, until evaporation, condensation, and the descent of rain had begun; until the rending forces of the atmosphere had weathered and decomposed the molten rocks so as to form soils; until the sun's rays had become so tempered by distance and waste, as to be chemically fit for the decompositions necessary to vegetable life? Having waited through those Æons until the proper conditions had set in, did it send the fiat forth, 'Let life be'?"

A little imagination will suffice to show that this is not a fair in the sense of a full statement of the question. First, the Professor describes a series of processes, conducted by secondary causation, and then he asks, "Did life arise from these causes, or did a special interposition take place for its introduction under the form of a fiat, 'Let it be'?" Scientific evidence is all through in favour of an appeal to secondary causation, not excluding a primary cause, but rather pre-supposing it; only expecting that the primary cause will be found throughout the system of nature to work in and through what men call *means*.

Science at present gives us no clue whatever to a reply to the questions, what *is* life, and how did it begin, nor does it show us any beginning of matter or force. If the Professor's imagination leads him to conjecture that thought and emotion, intellect and will, are forces correlative with light, heat, and electricity, ours does not act in that way. We see as yet no symptom of *physical* connection between the two sets of phenomena as relates to their essence or their action. We see that there is *some* connection between nerve-force and mental phenomena, but so long as Science cannot explain it, or even give a probable guess concerning it, we prefer a frank confession of ignorance to a depth of insight, which is a mere pretence.

The questions propounded by the Professor go beyond physical science. Before we can advance a step towards their solution we

want a clear definition of what life is, what matter is, if it is, and how the forces we call material stand towards those, which defy all our physical investigation.

The introduction of life at a given period may be the admission of a new force, or it may not. In either case we think an unchangeable order of nature was most likely observed, but whether Plato and Shakespeare had potential existence in a nebulous particle a long while ago, we are content in the present state of our ignorance to leave to such imaginations as Professor Tyndall may think worth cultivation. Our imagination inclines to view Intelligent Will as the ultimate and only real, as distinguished from phenomenal, force.

FOREIGN SCIENCE.

THE Nais-worms so frequently come under the notice of microscopists, that M. Edm. Perrier's observations on their fission (scissiparity) will be sure to interest our readers. M. Perrier says that the opinions of Gruithuisen, O. F. Müller, Leuckart, and Max Schultze, although differing in some particulars, agree in the main, as follows: Naiads present alternately two modes of organic generation; a single individual divides itself, first into two others of equal length, after which each of these individuals produce another from his posterior end by way of budding. Observations made by M. Perrier on *Dero obtusa* led him to point out another mode of increase. Whilst chains of three or four individuals of the species *Nais proboscidea* are frequently found, he has never seen more than two of *Dero obtusa* placed end to end—the head of the posterior individual and the tail of the anterior one are found exactly as Max Schultze indicates in the Nais. These two individuals separate before we can discover any symptom of fresh scissiparity, but in part of the respiratory apparatus at the end of the body, so long as the animal has not reached the adult stage, are numerous animals in process of formation, in which we can follow the development of the setigerous sacks, respiratory organs, muscles, etc. When the two separated individuals have acquired sufficient length, the median scissiparity recommences as in the single individual at whose expense they were formed. As this phenomenon only occurs when the animal has reached a certain length, it follows that the posterior individual of the second generation is formed of rings that were not developed until after the separation of the individual of the first, and

constituted an integral portion of this individual at the time they were produced. Thus, the Dero begins by enlarging itself through the formation of rings in advance of the vibratile tail, and then engages in scissiparity. This established, let us suppose the two Deros of the first generation did not separate after their individuation, and then the individuals of the second generation would be produced from the vibratile organ and the rest of the bodies of each of the individuals of the first generation, and each of the new individuals would be formed by means of rings produced after the individuation of the two primitive Deros. We thus fall back upon the law explained by Max Schultze as operating in *Nais proboscidea* without invoking any other budding than that which constitutes the normal growth of the annelid in question.*

Some experiments on bone growth detailed in the French Academy by M. F. Papillon, show that pigeons fed with food containing phosphate of strontium, transfer portions of that substance to their bones, and that alumina can be added to bones by a similar process.

MM. Rabonteau and Peyre report to the French Academy experiments made with the *m'boundoa* or *icaja* poison used for ordeals in Gaboon. The plant was found in a moist soil thirty leagues inland, near the river Como. The root is from fifty to seventy centimetres long and from one to three wide. The bark is reddish, and the colour below the epidermis is bright red. The wood is greyish white and hard. The experiments were made chiefly with the bark, but some with the wood and root. Infusions even when very dilute, are extremely bitter: with iodide of potassium or phospho-molybdic acid, they yield abundant precipitates, and contain one or more alkaloids. Alcoholic extracts were found more powerful than aqueous ones. A dog made to swallow twenty-five centigrammes of extract dissolved in water, remained sensible to caresses and came when called, but could not get up steps eighteen centimetres high. He trembled and suffered violent tetanic convulsions. An hour after more convulsions came on, but in two hours he only suffered from a slight stiffness in the limbs, and eat with a good appetite. Forty centigrammes of the extract killed a dog in 20 minutes. He died of asphyxia in the midst of convulsions. The action of this poison is exceedingly rapid, but fatal consequences may be prevented by artificial respiration, and it is soon eliminated.

MM. J. E. Planchon and J. Lichtenstein describe investigations, showing that the phylloxera of the leaves and of the roots of the vine

* "Comptes Rendus," 13th June, 1870.

is the same insect; and the latter advises as a means of preventing loss in vineyards to search out in May and August all leaves infested with phylloxera galls, and burn them.*

M. E. Roze states that he has successfully repeated J. M. Œrsted's experiments on the transformation of the Podisoma of the savin into the *Ræstelia penicillata* of the pear-tree, and he finds that *P. clavariæforme* of the juniper produces *R. penicillata* on the hawthorn. *P. fuscum* gave a negative result, and he thinks it may select some other tree of the apple family to produce a third species of *Ræstelia*. Experimenting with ergot of rye, buried in the winter, and kept constantly moist during the spring, he obtained in the open air *Claviceps purpurea*,† from the end of April to the end of June, as others have done; but ergots of the year before last produced no claviceps, and those of the last harvest, placed in the earth at the end of April, gave the same result. Ears of rye rear the *Claviceps*, and in process of normal development, were only attacked in small numbers by the *Claviceps* spores. M. Roze states that the spores of the claviceps experience a certain difficulty in transporting themselves to the parts of the flower (the stigmata especially) they infest; but that the "onidiophore juice of the sphacelium, with help of rain and wind, propagates the parasite actively." He advises cultivators never to sow the rye grains from the harvest of the same year.

Amongst the researches into the action of minute organisms, we may mention that M. Pasteur's tracing the most fatal disease of silkworms to the presence of minute bodies, probably allied to fungi, and his method of selecting moths and eggs free from these objects, receives the highest commendation from Italian and French growers. The pecuniary results of this application of the microscope are enormous in the aggregate. A trial on a large scale was made by order of the French Government, and M. Pasteur reports, that 100 ounces of silk with eggs were obtained from three persons, who operated by selection according to his process. They were distributed amongst the cultivators of the silk estate of Villa Vicentina, near Trieste, in lots of mostly of one and two ounces; one lot consisted of three ounces, another of five, and twenty-five ounces were reserved by the managers for a great experiment. M. Pasteur says, "The practical application of my method consists essentially, 1st, in obtaining an egg perfectly healthy, as much as possible *cellular*,

* "Comptes Rendus," 1st and 8th August.

† This is the Cordiceps purpurea of Fries, and is so called by Berkeley. (British Ichthyology.)

for the work of reproduction; 2ndly, to obtain for rearing eggs resulting from these arrangements for reproduction, which fulfil the following conditions: an excellent progress of the worms from the fourth month, *à la monte à la bruyère,* joined to a complete or nearly complete absence of corpuscles in the moth." The Villa Vicentina trials resulted in thirty kilogrammes of cocoons to the ounce of eggs, one and a-half times as much as the mean of average good years. The twenty-five ounces reared by the managers gave thirty-nine kilogrammes to the ounce. The average of thirty ounces would have been much higher if many of the cultivators had not made divers mistakes, overheating, etc.

Perhaps the virus of vaccine matter may be somewhat like the "corpuscles" of M. Pasteur, so fatal to silkworms. At any rate, M. Melsens considers it one of the ferments, and tells us that he placed four capillary tubes containing vaccine matter and closed with sealing wax for an hour and a-half to a temperature of 78° C. below zero, and upon using the matter contained in three of the tubes for purposes of vaccination, they produced the characteristic pustules.

M. P. Bolestra has communicated to the French Academy some observations on ague poison. He says, that in examining marsh water he always finds, in proportion to its degree of putrefaction, a granular microphyte, somewhat resembling in form the *Cactus Peruvianus.* It is always accompanied by a considerable quantity of small spores $\frac{1}{1000}$ of a millimetre in diameter, greenish yellow and transparent, and also by sporangia or vesicles containing spores from $\frac{2}{100}$ to $\frac{2}{300}$ of a millimetre in diameter, and of very characteristic form. This plant grows on the surface of the water; when young, it is rainbow-like in tints, and looks like spots of oil. At the low temperature of cellars and in water containing no vegetation, it developes slowly, but in contact with air and exposed to solar rays in the presence of decomposing vegetation, it grows fast, disengaging small gas bubbles. A few drops of arsenious acid, sulphite of soda, or, still better, neutral sulphate of quinine, stops its vegetation at the surface of the water, the spores become thin and transparent and the sporangia alter so that they would not be recognized. These changes may be seen under the microscope. M. Bolestra states that these spores can be found in marsh air. He caught agues twice during his researches—once after having been exposed to air from water in fermentation covered with fresh algæ in full vegetation, mixed with an extraordinary quantity of spores. He thinks these spores constitute the ague poison.

Amongst the most remarkable of recent discoveries relating to minute organism, is that of M. Béchamp,* and of a mould capable of producing alcohol from air and water. He thus describes the process :—"I took very pure distilled water, and exposed it to contact of air in a phial closed with paper. Colourless moulds appeared, formed of microzymas, very small bacteria, and an extremely fine mycelium. The apparatus was put on a stove, and at the end of six months I obtained enough alcohol to give a large flame. At the same time a good quantity of volatile and ammonia were formed. . . . . . Shall we say that distilled water, carbonic acid, and the elements of air have fermented? Evidently not; but we may say that the moulds grew and effected the synthesis of the materials composing their own substance, as all vegetables do, and that they then gave off (*désassimillé*) the alcohol which they formed by aid of this substance."

From experiments made by MM. Becquerel in the *Jardin des Plantes*, it appears that at a depth of 31 to 36 mètres, the seasons exercise no influence on the distribution of heat.

Between 26 and 16 mètres, the maxima and minima of temperature occur in summer and winter as in the air.

From 11 to 16 mètres the maxima and minima show themselves in autumn and spring, and at one mètre as in the air. At 16 mètres, in the locality of the experiments, the sheet of water which supplies the wells of the garden, and flows towards the Seine, is met with. This water is directly recruited by rainfall. At 26 mètres, a lower stratum of water is met with resting on the plastic clay.

The heat of last July will not be easily forgotten. At Poictiers on the 24th, M. Contejean found the extreme temperature in the shade in a large garden reach 41°·2 C. His instrument, he says, was only graduated to 41°, so he could not try the temperature in the sun. We suppose the graduation in the length of the tube enabled him to estimate the 41°·2 C. of which he speaks. The highest point was reached at 1h. 10m. p.m. During two and a half hours the average was 40°·3 C. All objects in the shade fell when touched, as if they had been exposed to the sun. The narrator says, "for the first time in his life he saw the thermometer go down several degrees when he held the bulb between his fingers or put it in his mouth."

When M. Renan accompanied the French army in Syria in 1860, he discovered, amongst other things, a fragment of a sun-dial at Oum-el-Awuvonid, some leagues south of Tyre. M. Laussedat

* "Comptes Rendus," 4th July, 1870.

restored the pattern of this dial, and exhibited a model to the French Academy, and confirmed what M. Bertrand had previously said about it. It belongs to the class of conical dials, and M. Laussedat noticed that one of the horary lines was straight, and that the two others entering the base of the cone and the arcs of the circle parallel to it, at centre angles, were not so. The straight line was undoubtedly the meridian; and the size of the arcs cut by the horary line, showed they were not intended to indicate equal hours, such as we use, but *temporary hours*, employed by most of the ancient nations. A "temporary hour" is a twenty-fourth part of the interval between sun-rise and sun-set, whatever may be the season.

Professor Lippich has been engaged in a study of the causes whereby the lines of the spectrum are increased in breadth. He traces the phenomenon to a progressive oscillation of gaseous molecules (as given in the theory of Clausius). While some of these molecules recede from the observer in the direction of the spectroscope, others approach him, the former emitting more, and the latter less refrangible waves; while molecules moving in any other direction emit rays whose value lies between those two limits, and each coloured band of the spectrum has, consequently, a determinate breadth. This breadth, however, must alter with the temperature and specific gravity of a given gas; which, again, is dependent on the intensity of the motion of the gaseous molecules. On this basis Lippich founds a mathematical calculation, the result of which is, that "The relation between the difference of wave-length, corresponding to the edge of the spectral line, to the mean wave-length of the line, is constant for all lines of one and the same gas; and, among different gases, is directly proportional to the square-root of the absolute temperature, and inversely proportional to the square-root of the density." Such differences are excessively minute; but the author points out, as a practical consequence of his investigation, that when lines of different breadth are seen in the spectroscope, we must be dealing with at least two different substances.

It is now a considerable time since Wiedemann and Franz announced that metals and alloys have the same conductivity for heat and electricity. This conclusion was disputed by Forbes and Angstrom, who, however, subsequently admitted a source of error to have existed in their experiments. Lenz has examined the question anew, using copper, brass, iron, etc. He finds that the conductivity of different bodies for heat and electric conductivity are proportional to one another at like temperatures, and that this

law is more valid than might be inferred from Wiedemann and Franz's experiments. The influence of temperature is the same on both of the properties referred to.

Since the discovery of isomorphism by Mitscherlich, crystallography has not undergone any development of general importance. Groth has, however, quite recently resumed the study of the relations between composition and crystalline form, and has already obtained results of much interest. The material for his work has been judiciously chosen from the systematized region of organic chemistry, his conclusions depending partly on his own researches, partly on those of others, in connection with the benzol series. In this group it appears that the introduction of any foreign element or elements into a substance in exchange for hydrogen is always attended with an alteration of crystalline form. Amongst rhombic crystals it generally occurs that such an exchange only affects one of the axes, leaving the ratio between the other two undisturbed. Groth seems also to have convinced himself that isomeric compounds are not isomorphous.

Helmholtz and Baxt, in the course of their investigation on the velocity of transmission of nervous impulses, found, by producing an irritation at a remote spot and then at a point nearer to the contracting muscle, the rate in question to be between 31·53 and 37·49 mètres per second. Comparatively recent experiments, of which the details have now been published, led to the discovery of what was at first believed to be an experimental error, but has since received an approximate explanation as a systematic phenomenon. It is found that the rate already mentioned applies to a cold winter, whereas a mean value of 64·56 mètres is the number obtained in a hot summer. As this result evidently pointed to temperature as the determining cause of the change, special and very varied experiments were made on the same day at very different temperatures. These fully establish the rule, that the velocity of (motor) nervous transmission is about twice as great in winter as in summer.

The electricity of clouds has been the subject of an attentive and laborious inquiry by Dellmann. He employed a Thomson's electroscope, with subsidiary arrangements enabling him to determine the intensity of every part of a passing cloud. Dellmann's conclusions will be of much interest to meteorologists. All clouds are electrical, and oppositely so in different parts; they are negative at the centre, which is begirt with positive zones. The intensity of the electricity increases from the outside to the interior; but its maximum is not at the centre of the cloud. A sudden decrease of

the one kind of electricity corresponds to an equally abrupt increase of the proximate opposite kind. *A cloud can only rain by virtue of a loud or silent electrical discharge.*

Cappel has been engaged in determining the influence of temperature on the sensibility of spectral reactions. To this end, he contrived an apparatus in which the induction spark was passed between electrodes consisting of bundles of platinum wires, the negative pole being kept continually moistened with solutions of successively increasing dilution. Each experiment was continued until (with the exception of copper salts) only a single characteristic line was recognizable. Comparing his own results with those previously obtained by Bunsen and Kirchoff with a gas flame, Cappel makes the following inferences. As the temperature increases, so do the number of lines and the sensibility of the reaction to a certain point, above which both decrease. Abundance of lines and sensibility are correlated phenomena in one respect, viz., that the maximum of the one accompanies that of the other. The degree of temperature at which the maximum of sensibility occur is different for different metals, and, on the whole, rises from alkalies to the electro-negative and of the series of metals.

GLANCES AT NEW BOOKS.

Dr. Tyndall has published his papers* on "Diamagnetism and Magne-crystallic Action," which have appeared during the last eighteen years in the "Philosophical Magazine and Philosophical Transactions," in an octavo volume of some four hundred pages, with numerous diagrams and illustrations. These papers show an enormous power of work, coupled with great skill as an investigator, and there is no doubt that the Professor has nobly maintained a foremost position in the competitive struggle to arrive at the truth. A more perplexing and difficult work has rarely tasked the ingenuity of the experimenter or the logical faculties of the industrious reasoner. The work now issued also comprises letters of various scientific men engaged in the same line of research, together with a paper by Faraday on Magnetic Polarity. We hope Professor Tyndall will

* "Researches on Diamagnetism and Magne-crystallic Action, including the Question of Diamagnetic Polarity." By John Tyndall, LL.D., F.R.S., Professor of Natural Philosophy in the Royal Institution. (Longmans.)

some day put the entire subject in a new shape; doing for it in fact what he has already accomplished for Heat and Sound, and giving us a treatise that will be accepted as the best text-book and guide to this branch of science. It is always gratifying in Tyndall's books and lectures to note his hearty recognition of Faraday's extraordinary powers and merits, and in no case were they displayed more strikingly than in his magnetic researches. Dr. Tyndall says, "In the year 1846 our views of magnetic action received, through the researches of Faraday, an extraordinary expansion. The experiments of Brugmans, Le Baillif, Seebeck, and Becquerel, had already proved the power to be active beyond the limits usually assigned to it; but their experiments were isolated and limited in number. Faraday was the first to establish the broad fact that there is no known body indifferent to magnetic influence when the latter is thoroughly developed. The nature of magnetic action was then found to be twofold—attractive and repulsive; thus dividing bodies into two great classes which are respectively denominated *magnetic* and *diamagnetic*. The representative of the former class is *iron*, which being brought before the single pole of a magnet, is attracted; the representative of the latter class is *bismuth*, which being brought before the single pole of a magnet, is repelled. If a little bar of iron be hung freely between the two poles of a magnet, it will set its longest dimensions in the line joining the poles; a little bar of bismuth, on the contrary, will set its longest dimensions at right angles to the line joining the poles." The great difficulty was to discover what kind of force produced the diamagnetic effects, and at last it was shown by Professor Tyndall and others to be of a polar character, and having special relation to the molecular constitution of the bodies it affected.

Professor Tyndall has also published two good cheap and convenient little volumes called "Notes on Light," * and "Notes on Electricity," † which were originally prepared for students attending his lectures. The compact way in which the principal facts are stated and phenomena explained, will make these works peculiarly acceptable to a very numerous class of teachers and pupils.

Passing to quite another class of subject, we are very glad to find Mr. W. Robinson, F.L.S., advocating the return to something

* Notes of a course of Nine Lectures on Light, delivered at the Royal Institution of Great Britain, April 8—June 3, 1869. By John Tyndall, LL.D., F.R.S. (Longmans.)

† Notes of a course of Seven Lectures on Electrical Phenomena and Theories, delivered at the Royal Institution of Great Britain, April 28—June 9, 1870. By John Tyndall, LL.D., F.R.S. (Longmans.)

like natural principles of gardening. His "Wild Garden"* is an excellent periodical work, showing "how to make our groves and shrubberies beautiful" by a judicious cultivation of hardy exotics, and by the introduction in appropriate places of English wild flowers possessing sufficiently characteristic merit.

Mr. Robinson says, "About a generation ago a taste began to be manifested for placing a number of tender plants in the open air, in the summer, with a view to the production of showing masses of decided colour. The subjects selected were mostly from sub-tropical climates and of free growth; placed in the open air of our genial early summer, and in fresh rich earth, every year they grew rapidly and flowered abundantly during the summer and early autumn months, until cut down by the frosts. The brilliancy of tone resulting from this system was very attractive, and since its introduction there has been a gradual rooting out of all the old favourites, in favour of the bedding system.". The introduction of half-hardy exotics need not have lead to the wearisome sameness of modern gardening, and nothing can be more ridiculous than the practice for many years past for thousands of people, in all sorts of situations, to imitate what is done in portions of large grounds, such as those at Kew or the Crystal Palace, where the bedding system is subordinate to picturosque landscape effects. Great numbers of persons who spend large sums on their gardens have nothing in them worth looking at for half the year, and when their beds are filled with patches of scarlet, yellow, and blue, they weary the eye of everybody who is condemned to do more than give them a passing glance. What possible pleasure can there be in walking about grounds that are destitute of variety, and show profound ignorance of picturesque art. When a house has a decided architectural character, the garden in its immediate vicinity should, of course, be formed so as to suit the style, and a certain regularity, or even stiffness, will in many cases be required; but, if the piece is of any size, pictorial effects arising from judicious contrasts of form and colour should be provided all the year round. A real garden in a temperate climate should look as beautiful, if not as gay, in January as in June; and we have a notion that gardens ought to be characteristic of their owners' tastes—what they usually demonstrate is, that he has no

* The "Wild Garden; or, Our Groves and Shrubberies made beautiful by the Naturalization of Hardy Exotic Plants; with a Chapter on the Gardens of British Wild Flowers." By W. Robinson, author of "Alpine Flowers for English Gardens," "The Parks, Promenades, and Gardens of Paris," etc. (J. Murray.)

taste, but can spend money in something like imitation of the fashion, whatsoever it may be.

After general remarks Mr. Robinson supplies lists of a great variety of plants, hardy exotics and indigenous, with short notes of their peculiarities, the treatment they require, and the localities they are fit for. This work will be found of great use to those who wish for a garden which will be a perpetual delight.

Mr. Shirley Hibberd, who is indefatigable in successful effort at pleasantly instructing the public in all floral matters, has added to his previous work a charming little book on "Field Flowers,"* illustrated by eight handsome coloured plates and ninety wood engravings. We could not point out a more agreeable way of spending pleasant hours in the country than in hunting for the wild flowers in Mr. Hibberd's list, and with the help of his instructions. He has mingled botanical science and æsthetic sentiment with his accustomed skill; and the publishers have very judiciously given his work the advantage of fine printing, good paper, and handsome binding. Each of the months, except the last two, have chapters devoted to their floral characters. Among the directions for drying plants is one which we think is little known, and which we therefore cite: "Prepare several tablets of plaster of Paris of the size of the book the specimens are to be mounted in, and full an inch in thickness. These should be made by a worker in plaster, who, if instructed to work them *very light*, will produce a sort of plaster sponge. In drying plants, first warm (and be very careful not to crack by too sudden exposure to heat) one of these plates; on it lay a sheet of warm paper, then a plant, next paper, plate, plant, and so on. In two hours you may repeat the process, and twice warming will suffice for almost any class of specimens, however succulent. The plaster form preserves the natural colours most beautifully, the reason being that it quickly absorbs every particle of moisture from the plants." For preserving fungi, Mr. Hibberd recommends bedding them in silver-sand, gills upwards, in small tin boxes, and placing the boxes in a slow oven for two or three hours. Mr. Hibberd's "Wild Flowers" contains many hints and suggestions that may lead to the cultivation of some of the more beautiful and interesting. In one place he exclaims, "What a pity we do not often meet with collections of interesting hardy plants, instead of ephemeral flimsy things, ten thousand times repeated in the grounds

* "Field Flowers, a Handy Book for the Rambling Botanists;" suggesting what to look for and where to go in the out-door study of British Plants. By Shirley Hibberd, author of the "Fern Garden,' "Rustic Adornments," etc., etc. (Groombridge and Sons.)

that embellish our rural residences! Fashion, however, was never much of a friend to knowledge; hence, to follow the fashion does not require any considerable amount of brains."

The Rev. W. Lucas Collins presents us with another of his excellent classical series. This time it is "Virgil,"* edited by himself. The task was to have been performed by Mr. Conington, but death interposed, and Mr. Collins has done well to take his place. Virgil, so much admired by successive generations of scholars who can read his elegant verse in the original tongue, can scarcely be made to satisfy the expectations of English readers in any translation; and the chief reason is, that we have passed into a new stage of poetry, and that, apart from special felicities of diction, we are not disposed to care much for what, in his epic the Roman imitator of Homer had to say. His "pious Eneas" is a very tiresome, shabby fellow, and we find it difficult to sympathize very strongly with Dido, though she ends grandly, and is greatly preferable to the hero of the poem. Mr. Collins treats the Georgics as poetical essays on the dignity of labour. "Warlike glory was the popular theme of the day; but Virgil detests war, and he seeks to enthrone labour in its place. He looks upon tillage as in some sort, a war in itself, but of another kind—'a holy war of men against the earth,' as a French writer expresses it. He compares its details, in more than one passage, with those of the camp and the battle-field; but besides this the Georgics contain what seem to be a protest against the fashionable atheism of his age. He sets the worship of the gods in the first place of all; 'First pay all reverence to the power of Heaven,' is his instruction to his pupils; 'from Jove all things begin.' His motto might have been that which the Benedictines in their purer days adopted, 'Love and labour, pray and work.' It has been commonly said, that Virgil was in his creed an epicurean, and that he looked upon the gods as beings, who in our English poet's words, 'Lie beside their nectar careless of mankind.' But a study of his writings will go far to show that such was not the case, that whatever the distinct articles of his creed may have been, he had a deep individual sense of the personal existence of great powers which ruled the affairs of men; the world was not to him, as to Lucretius, a mere shrine of hidden mysteries, unlocked to the epicurean alone, but that he had an eye and a heart for all its riches and beauties, as the 'skirts' of a divine glory. In all his verse this feeling shows itself, but never more than in the

* "Virgil." By the Rev. W. Lucas Collins, M.A., author of "Etoniana," and the "Public Schools," etc. (Blackwood and Sons.)

Georgics." Apart from the toadyism to "Cæsar," there is much in the Georgics with which modern feelings can agree, and many of the passages which Mr. Collins has selected give an excellent idea of the vigour of the style, and the glowing anticipation of human progress, in which the poet indulged. The most remarkable illustration of this frame of mind is found in the Pollio, of which Mr. Collins gives a good translation, and which many of the early Churchmen took for a prophecy of Christ. Scholars have been puzzled to know who the "child" was by whose aid Justice was to return to earth, and for whom "the earth untilled, should pour her early gifts," and under whose influence, the poet addressing him says—

"The herds no longer fear the lions spring;
The ground beneath shall cradle thee in flowers,
The venomed snake shall die, the poisonous herb
Perish from out thy path, and leave the almond there."

The most probable conjecture is that Augustus was the child, and that under the guise of prediction Virgil meant to describe the hopes excited by his reign, and the good things he wished to recommend him to accomplish.

Mr. Collins' last labour will materially help English readers to understand how the old Homer poet influenced our own writers, Spencer, Milton, Pope, etc., etc.

Our readers will recollect some excellent papers on Grave-mounds by Mr. Jewett, and will be glad to find that he has now treated the subject of the burials of the Celtic, Romano-British, and Anglo-Saxon periods,* in a richly illustrated and very readable volume, full of curious matter. Scattered all over our country are the memorials of our ancestors, of various races, left in the tombs they constructed for their dead. Much of the best part of history—that which relates to manners and customs, progress in fertile and other arts—would be lost if it were not for objects found in graves, and which, like the fabled ever-burning lamps, shed a clear light upon the past. Mr. Jewett is a good narrator as well as a skilful antiquary, apt at interpreting ancient remains, and well practised in opening barrows and studying their contents. It is extremely interesting to compare the relics discovered in various localities of the prehistoric men with those found in the burial places of races that belonged to a much later period, long after the earliest known civilization came in full force. Thus the sepulchral urns of the

* "Grave-mounds and their Contents: a Manual of Archæology, as exemplified in the Celtic, the Romano-British, and the Anglo-Saxon periods." By Llewellyn Jewett, F.S.A., etc., etc., with nearly six hundred illustrations. (Groombridge and Sons.)

Celtic period (Ancient British), which frequently contain flint implements, closely resembling those of much earlier dates, are by no means destitute of a rude kind of skill and taste. In some urns of later date bronze implements occur, and something like elegance of form is attained. The great care taken of the dead, and the valuable objects buried with their remains, and the large amount of labour required to pile up the mounds beneath which they rest—all evince a progress in religious ideas far greater than that which Sir John Lubbock is disposed to recognize in most of the savage races he describes. The abundant illustrations which adorn Mr. Jewett's work will readily enable those who may not have access to good museums to form sound opinions on the progress, from anything like barbarism in many of the old Celtic works. A good deal of the pottery of this early time is worth study by the manufacturers of our own days. Some of the necklaces of the old British ladies, which he figures, likewise show considerable progress in jewellery as a fine art. When we come to Roman times we find inscriptions of a very tender and touching character, contrasting very favourably with the rubbish so often inscribed on the modern tombstone. One at York runs thus: "To the Gods of the Shades. To Simplicia Florentina, a most innocent thing, who lived ten months. Her father, of the Sixth Legion, the Victorious, made this." Another from Carvoran, in Cumberland, is thus affectionately worded: "To the Gods of the Shades. To Aurelia Faia, a native of Salona, Aurelius Marcus, a centurion, out of affection for his more holy wife, who lived thirty-three years without any stain." Mr. Jewett quotes, with a translation, a most interesting poem describing the obsequies of Beowulf, and there is something truly grand in the narration, how, after making "the mightiest of funereal pyres, from which the smoke rose aloft, dark from the fire, mingled with weeping," they piled up the mound so that it

> "rose high and broad,
> by the sailors over the wave,
> to be seen afar,
> and they built up
> during ten days
> the beacon of the war renowned.
> They surrounded it with a wall
> in the most honoured manner
> that wise men could desire
> * * * *
> * * * *

They suffered the earth to hold
the treasures of warriors'
gold on the earth,
where it yet remains
as useless to men
as it was of old."

With this fine bit from an old Saxon Homer, we must leave Mr. Jewett's capital book, and pass to quite another theme, that of Microscopical Manipulation,* as explained by Mr. Suffolk, who has treated the matter in a way that will be very helpful to beginners in such pursuits. Mr. Suffolk is well known in scientific circles for practical skill, and he has brought together much valuable information concerning microscopical apparatus, mechanical processes, modes of mounting, polarization, drawing, micrometry, etc., etc.

PROGRESS OF INVENTION.

TREATING SUBSTANCES FOR MANURE.—Dr. James Dewar, of Kirkcaldy, thus describes his method of treating bones, coprolites, and shells of fish, which contain valuable constituents for manures: —"I subject them to the action of the alkali waste called soda ley (such as is obtained from the soda used in preparing rags, esparto grass, and other materials for the manufacture of paper), by steeping them in it. In using soda ley, I utilize a substance which is generally lost, and which, when it finds its way into rivers, may be deleterious. By the action of the ley the bones, coprolites, and shells become friable and more easily soluble, and are thereby rendered more suitable for manure. When I wish to prepare a manure which shall be slow in its action, or what is known as a 'nursing' manure, I subject the bones or other substances to a shorter treatment with the soda ley, and I find that if they are broken or reduced to small pieces, and are then subjected to such a length of treatment with the ley as to leave them in a partially decomposed condition, they are very suitable for manure of that description. When I wish to prepare a manure which shall act more rapidly, I make the treatment with the soda ley longer, and

* "On Microscopical Manipulation, being the subject matter of a course of Lectures delivered before the Quekett Microscopical Club, January to April, 1869. By G. S. Suffolk, F.R.M.S. (H. Gilmore.)

this also facilitates the process of grinding or crushing. The soda ley absorbs a portion of the gelatine and phosphoric acid contained in the bones, and the product forms a strong manurial compound, which may be used either separately or mixed with other substances, treated as before explained. The operations are more rapid if the substances are *boiled* in the ley.—

SCALE-BEAMS.—This very useful invention relates to beam weighing machines, and consists in the employment of mechanism below the scale which carries the weight, for enabling the goods scale to be firm on the floor when it is loaded or unloaded, and to be afterwards set free for enabling the weight to be determined. The beam is balanced on a support, and carries the scales in the usual manner, and, when not acted upon by the mechanism, is free to oscillate as required. Below the scale which carries the weight a plate is employed, which is fixed to a vertical rod, having at the bottom a bowl in contact with an eccentric fixed to a shaft working in bearings attached to the box or frame which carries the pillar or support of the scale beam, and to the shaft is fixed a long lever in contact with a spring. When the lever is placed in one position, the plate is below the scale and the beam is free, but when the goods have been weighed and require to be removed, and fresh goods placed on, the lever is turned to cause the eccentric to raise the plate and weight scale, and lower the goods scale until it rests on the floor and thus enables heavy articles to be put on and taken off the scale with great ease, and without the labour of removing weights. This simple and useful contrivance has been patented by Mr. B. Clarkson, of Manchester.

PAINT.—A very desirable paint has been invented, which has no disagreeable smell like that in ordinary use, and will for this reason no doubt become popular. Instead of using ordinary linseed oil and turpentine, to which the unpleasant smell of ordinary paint is owing, it is proposed to employ as a vehicle a composition made by combining alcohol, shellac, and a vegetable oil (castor oil is preferred). This vehicle is then mixed with white lead or other pigments to form paint. The proportions in which the several ingredients are mixed is as follows:—Eight parts of alcohol, two parts of shellac, and one part of vegetable oil. They are gently heated together, and stirred until the shellac is dissolved. This paint is inodorous, dries very quickly, and is not liable to crack or blister by exposure to heat.

TREATING XYLOIDINE.—Mr. Daniel Spill, of Paradise Terrace, Hackney, describes an improved method of preparing Xyloidine of an improved colour, whether it be produced from fibres or

materials in their normal condition, or when coloured or dyed; and it consists in subjecting xyloidine, or soluble gun-cotton, produced from such materials, to the bleaching action of sulphurous acid, chloride of lime, chlorine, or bleaching agents generally.

PRESERVING BREAD.—Bread becomes mouldy and sour from the action of the moisture it contains. When carefully dried, bread will keep sweet for a very long time. Any process by which fermented bread can be preserved for an indefinite length of time would be a great boon to travellers in countries where bread cannot be procured, and to sailors, who would find it a very agreeable change from ordinary ship biscuits. The following process for effecting this object has been lately patented, and it possesses this advantage, that the bread being compressed can be packed in a smaller compass, and is therefore very portable. Well-made and well-baked bread is exposed to a current of dry air; the evaporation of the moisture should be slow, in order that the bread may not crack. The duration of this drying process varies from eight to fifteen days, and depends on the size of the loaves and the form of drying apparatus adopted. If the bread were compressed in the state in which it is left by the dessication it would break; and to prevent this it must, before being pressed, be submitted during four or five minutes to a heat of from 150° to 200° C., in a stove filled with steam. To effect this operation the bread is arranged in layers, separated by iron plates, which form moulds in which the bread will assume the shape and size previously determined upon. These layers are loaded upon a cast-iron carriage running upon rails, and thus introduced into a stove which is immediately closed, in a few minutes the bread becomes soft, although it will have absorbed but a very small quantity of water; the load or batch, is then withdrawn and pushed by means of a carriage between two pressing plates, in order to be compressed. Any press will serve, but as the pressure should be rapid and powerful the hydraulic press is best. The bread should remain in the press for twenty-four hours; it may then be removed, is dry and cold, and will preserve the shape which has been impressed upon it. Bread thus prepared should be put in cases to preserve it from the attacks of insects, and should be stored in places free from damp, it may thus be preserved for several years. This compressed bread has a nice colour, the teeth masticate it without effort, the fluids of the mouth penetrate it rapidly, it has an agreeable taste and digests readily; a piece three ounces in weight, thrown into broth will absorb, in three or four minutes, fifteen ounces of liquid and swell considerably. The in-

ventor is Jean Joseph Auguste Mouriér, Boulevard Bonne Nouvelle, Paris.

PREPARING MATERIALS FOR MAKING SOUP, ETC.—In order the more conveniently to import extracts of meat from Australia, Mr. Whitehead has patented a process by which he produces compressed blocks of prepared animal and vegetable materials in a cheap form for making soup and other liquid food. The extract, or essence of meat, is mixed with some farinaceous material, such as vermicelli or tapioca, and is compressed by hydraulic pressure into cakes of such a size, that when one of them is boiled with water it will make one pint of good soup.

PREPARING COLOURING MATTERS.—The invention of Messrs. Richard Dale and Carl Schorleman, of Manchester. It consists in improvements in the manufacture of Alizarine from Anthracene. One part of anthracene is heated with from four to six parts of strong sulphuric acid, at the boiling point, for some time. It is then diluted with water and neutralized with a solution of carbonate of soda or carbonate of baryta, or some such substance. The sulphates are removed by crystallization. The resulting liquid is heated to between 180° and 260° C. with caustic soda or caustic potash mixed with nitrate or chlorate of potash, as long as a bluish purple colour is produced. Instead of nitrates or chlorates other suitable oxidizing agents may be used. Alizarine is obtained from this product by precipitation with an acid in the usual manner.

TRAMWAYS.—A tramway has been invented which consists of a single iron or steel rail of any section, ballasted up to the level of the road. Upon this single-rail tramway vehicles of any construction, and driven by any suitable means, may be run, but in order that the greater part of the weight of the vehicles may be carried by the rail, one or more double-flanged wheels are fixed on the centre line of the vehicle; each of these wheels work on a swivel attached to a screw, in order to raise or lower the framework or body of the vehicles above the surface of the ordinary road on either side, so that the whole or nearly all of the weight of the vehicles and their contents would rest on the rail, whilst their balance would be maintained on either side by the ordinary wheels of the vehicles. The centre double-flanged wheel or wheels are acted upon by springs on either side, in order to prevent jarring and jolting, and to give them a fair amount of play to suit the irregularities of the road, which would naturally affect the ordinary wheels of vehicles.

MEMORANDA.

BROWNING'S POCKET MICROSCOPE.—Decidedly one of the best of the portable microscopes, is that just issued by Mr. Browning, who, we believe devised it to meet a want felt in one of the Government departments. It has a folding tripod stand, a draw tube, a well made fine adjustment, which acts upon the stage, a spring clip to hold slides, stage forceps conveniently attached to the body, and substage mirror. The microscope with powers, dipping tube, forceps, hollow glass slide, etc., fits into a handsome morocco case easily carried in the pocket. We have had this little instrument in frequent use for several weeks, and can speak very highly of it. It is exceedingly useful in the country or in any situation where objects are frequently obtained, and require prompt examination, as it is sufficient for more purposes, and can be set up and arranged in less time than a larger and more complicated pattern. From its moderate price and convenience, it would be very handy for schools and families. A small bull's-eye should be added for use with a lamp.

CONFIRMATION OF JUPITER'S COLOURS: DR. MAYER'S OBSERVATIONS.—We mentioned in our last number the strange, and not very creditable conduct of Mr. Airy, in attempting to get rid of the facts of the remarkable colour changes noticed by Mr. Browning, and others, in the planet Jupiter, by a foolish, because scarcely relevant statement he inserted in the annual report of the Greenwich Observatory, to the effect that on some occasion they were not seen by one of his assistants, and that the idea of change was therefore negatived. Now we have before us Dr. Mayer's "Observations on the Planet Jupiter," made at Lehigh University, U.S. He commences by saying, "Every astronomer, who during this fall and winter (1869-70) has made careful observations of Jupiter, must have remarked the unusual colour of his disc and belts, and the remarkable forms and mutations which the latter have frequently presented." These remarks were founded upon *seeing:* Mr. Airy's *not seeing*, which appeared to negative the idea of any change in the colour of Jupiter's belts, is so discreditable to our national observatory, that we trust the Board of Visitors in the Admiralty will take such special notice of it, as may prevent anything of the sort in future.

Dr. Mayer's observations were made with a six-inch refractor by Alvan Clark and Sons, and one on January 5, 1870, when the sky was astronomically perfect, and definition so clear and steady that the six stars of the trapezium of Orion and the companion of Sirius were readily and continuously seen. At this time Dr. Mayer noticed "a ruddy elliptical line lying just below the south equatorial belt." He saw it first when it had advanced about half the major axis from the east limb. The ellipse became more distinct as it progressed to the centre, and Dr. Mayer followed it till it was almost bisected on the west line, when it gradually faded from

view. He considered that the irregular nearly detached masses forming the south equatorial dark belt, with their streamers pointing in the opposite direction to that of the planet's rotation, presented appearances which incline one to imagine them distinct masses of cloud or coloured vapour instead of openings in a cloudy stratum, disclosing the ruddy body of the planet, and this view, held by Mr. Browning and Mr. Proctor, was favoured by the elliptical form already described, and concerning which he says, "Can we be so bold as to regard it as a great gaseous mass, having its origin in the equatorial region, and sweeping south (as with the terrestrial cyclones of the southern atmosphere), and flattened with the rapid rotation of the planet with an equatorial velocity of 450 miles a minute." In another passage Dr. Mayer speaks of the irregular and violent changes in the southern equatorial belts, which took place last winter. On January 8 he entered in his note-book, "The south border of the southern equatorial belt was evidently divided into two, and on the 9th, "The division of the belt has increased rapidly. On the 21st, the southern division of this belt had drifted 8° in latitude to the south of the band which gave it birth," and "the south equatorial belt at this date presented the appearance of irregularly massed cumulus clouds, forming three distinct aggregations with blunted summits." In drawing the unusual colours, Dr. Mayer used pure yellow, yellow with crimson lake, and a very thin wash of light lead tint over the paler shadings.

Mock Sun.—A fine mock sun was seen by Mr. Slack from Ashdown Forest, Sussex, on July 8, at seven p.m. It was about 15° north of the true sun, orange yellow nearest the sun, and then white. After some time it elongated vertically, and very slowly faded. Working men in this neighbourhood frequently report seeing mock suns in the morning.

Aurora.—On Saturday, September 3, the Scotch papers report a fine aurora seen over a wide area. At Edinburgh it commenced about eight. "A thickness like a dense fog" appeared half way to the zenith from the northern horizon. As it crept upwards it became thinner, and long quivering waves of light shot from east to west, and at right angles to these thin spears of light. Innumerable light rays sprang from the convex rim of the haze. It began bright yellowish about ten p.m., when the moon set the effect was heightened, and the light was rich and purplish. On the same night an auroral display was seen by Mr. Slack at Forest Row about ten p.m., when the colour was crimson, with lighter beams radiating up from the horizon. At an earlier hour he noticed a peculiar white light springing up north of the sunset, and another patch of white light in the north-east, both commencing near the horizon.

THE EDIBLE FROG.

(*Rana Esculenta, Linn.*)

BY SHIRLEY HIBBERD.

(*With a Coloured Plate.*)

It is a question of some interest, requiring many considerations and some actual experiments for its solution, who has the best right to raise a laugh on the subject of frog eating—the Frenchman who eats, or the Englishman who does not? Numerous as are the differences in detail between the common dietary of the people of this country and those of the continent of Europe, there are only two striking differences of a primary nature discoverable, and in respect of those there can scarcely be a doubt that our position is that of disadvantage. The French eat frogs, and the favourite species for the table is the one here figured, the edible frog, *Rana esculenta* of Linnæus; and they also eat snails, the favourite species for the table being the great tempting apple snail, *Helix pomatia* of Linnæus. Having kept large numbers of both these despised cattle, it has occurred to me that a figure and a few remarks on the frog might be acceptable to the readers of the STUDENT, for I think I may venture to say that very few English people, even if of observant habits, are acquainted with the green or edible frog.

As the common frog, *R. temporaria,* Linn., is the common frog of Britain, so the green frog, *R. esculenta,* is the common frog of France. They are both, indeed, European and widely spread, and as our common frog is found on the continent, so the green frog of the continent has occasionally been met with in Britain, though it is decidedly scarce. Europe has but three species of frogs in all—the two here named and the exceedingly pretty tree frog, *Hylas arborea,* Linn., which has tuberculated feet which are not webbed as those of the Ranæ are.

The green frog would be pronounced by careless observers larger than the common frog, but it is not so. It is fully as large and far more handsome; its bright and beautiful colouring rendering it more conspicuous, and therefore apparently larger than our common species. It is eminently aquatic, and in this respect differs materially in habit from its British congener, which goes oftener upon land, and thrives in districts far removed from water. Another peculiar characteristic of this animal is extreme shyness, hence it is that those who procure frogs for the markets in France have to hunt in "melancholy marshes" and in the meres of sequestered woody

districts. My own colony of these frogs was kept in a froggery prepared for the purpose with an artificial pool and rockery containing many damp and dark hiding places, the whole being enclosed with boards, surmounted with a breadth of wire netting. Here they were happy, provided only they had care enough, but it was hard to tame them; indeed, common frogs and toads may be tamed with certainty in a few weeks, but I must confess that though I managed to overcome the extreme timidity of my beautiful green frogs, not one of them ever became so tame as to afford the shadow of an excuse for boasting.

As they spend the greater part of their time in the water, their habits could only be properly observed by patient and quiet watching; that they go through the same tadpole phases as other frogs need not be said. When their metamorphosis is complete, they feed ravenously and grow rapidly. The ordinary manner in which the creature passes both week days and Sundays is to sit on a leaf in the water where the sun shines brightly and wait for a fly, or beetle, or butterfly to come within range, when it is snapped and swallowed in much the same way as the toad supplies himself when his dinner honours him with a visit.

In the confined space that my frogs were kept, it was impossible for them to obtain a sufficiency of food, and therefore worms, woodlice, beetles, and other such delicacies, were provided for them. To see a frog take a worm is to be mightily amused, or dreadfully disgusted, according as the observer may be inclined to take things as they come, and in the faith that "Whatever is, is right;" or under the blighting influence of the prevalent notion that only pretty things should be looked for in nature, and that the so-called "ugly" things are errors of creation. The tongue of the frog is soft, and attached to the edge of the jaw folding inwards; it is necessary, therefore, for it to keep a worm in the centre of the mouth while performing the tedious process of swallowing it, which may account for the grotesque performance of the animal when a worm constitutes its dinner. Master Frog first points at the worm as if its movements surprised him. He then turns his head aside like a coxcomb, and views it sideways with one eye, just as we may sometimes see a parrot take the measure of a nut that has been thrown into her cage. By this time the worm has made another twist, and the reptile makes a dash at it, grips it, and instantly loses it, owing to its vivacious wriggling. After a pause of a few seconds another plunge is made, the worm is secured, and as it is too large and too lively to be bolted, the frog labours with his fore

feet to keep the worm in the centre of his mouth, and it is scarcely an exaggeration to say that he uses his feet in the manner of hands to poke the worm down his throat.

The green frog, in common with our own frog, passes a large portion of his time in the practice of rigid abstinence. It may be that both species feed freely from the beginning of June to the end of August, but it is highly probable that they never touch food through all the remaining nine months of the year; indeed, I never could persuade a frog to eat, except in those three months, and I have kept as pets very many of all the three European species. But while the desire for food is upon them they eat voraciously, and should have plenty, or they will be likely to die during their period of torpidity in winter.

As a pastime, with a view to utilitarian results, the keeping of green frogs and apple-snails proved with me a complete failure, for the simple reason, that to provide them with food occasioned more trouble than could be reasonably given. I entered upon the pursuit with the expectation of enjoying an occasional dish of delicate food, which the ordinary cuisine could not supply, but the frogs demanded extravagant supplies of insects and worms in the summer, and the snails required an abundance of lettuces from early spring until late in the autumn. But there was another objection to the frogs, and that was their music. The note of this frog has been described as resembling "a loud snore, exactly like that of the barn owl." I always thought—if the horrible din they made at night in the breeding season did not utterly stupify me—that it was a sort of infernal trumpeting with a nasal twang. The croak of an English frog is downright melody compared with it.

The green frog is such a beautiful creature that we might be justified in giving it special attention for that reason. It is, however, especially interesting, because of its employment as an esculent. It may be served up as a fricassee, and it may be made into soup. The cooking, however, is an important affair; it is a parallel case to the cooking of whitebait, which it is well known needs an experienced artist, or it is unfit to eat. In case any reader should be inclined to indulge a feeling of regret that the edible frog is not common in this country, the hint may be comforting that our British frog is every whit as good, and that, in fact, all frogs are edible, and every way worthy the attention of a skilful cook. *Experimentum crucis.*

WASPS ANCIENT AND MODERN.

BY EDWARD LATHAM ORMEROD, M.D., F.R.C.P.,

Physician to the Sussex County Hospital.

WASPS were the first paper-makers, but, unfortunately for their reputation, they never had the use of pen and ink to put their own good qualities on record. So they have been the silent suffering victims of an unjust judgment ever since their younger fellow-citizen of the world, Man, could read and write, and transmit his opinions. I am not going to inculcate sentimental zoology and to try to set them right in the world's estimation; but rather, I fear, while retaining my own conviction, to confirm this ill-feeling towards wasps by showing that they have always held the same hateful position as is assigned to them now-a-days: as far, at least, as the occasional notices of wasps, which have occurred to me in my reading, have allowed me to trace their family history.

Wasps have a long, though perhaps somewhat of a Welsh pedigree. The Pyramids of Egypt, the occupation of Canaan by the Israelites, the siege of Troy, and the fall of the Roman Empire, are all land-marks in their history. And the wasps over whom these great events passed were probably either identical with the present wasps of Western Europe, or so nearly resembling them as to be undistinguishable from them except by a practised eye. Their story, as presented in these pages, is written quite from a British point of view, to culminate in our own wasps, as we see and feel them now.

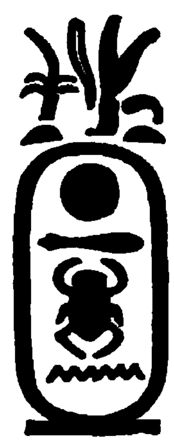
The storms of the world have not hurt wasps in their insignificance, they have reappeared like the barnacles on the rocks when the waves retired, to take and give, to be trampled on and wound in return, feared and yet despised through all ages, their bright redeeming quality being their intense domestic affection.

The insect which appears so often engraved on Egyptian monuments may be taken, from its form, either for a bee, a wasp, or an ichneumon fly, which last it most nearly resembles. Horapollo* distinguishes between the hieroglyphic representations of wasps and bees, and says, among other things, that a wasp on the wing denotes a murderer. But Mr. Sharpe, so well known for his successful studies of Egyptian hieroglyphics,† and whose kind assistance I

* "The Hieroglyphics of Horapollo Nilous," translated by A. T. Cory. Small 8vo. London, 1840, pp. 82 and 103.

† "Rudiments of a Vocabulary of Egyptian Hieroglyphics." 4to. London, 1837.

have great pleasure in acknowledging, tells me that Horapollo is not quite a safe guide, that his interpretations are not to be unreservedly adopted; and, with regard to the point under consideration, that there are no sufficient grounds for asserting that any distinction of bees or wasps was intended. In one figure,* indeed, the coincident emblems—honey-pots—make it most probable that a bee was intended. But such a coincident explanation is exceptional, and, as the rule, there is no allusion to the habits of the insect, whatever it may be, nor is any moral implied. The figure of the insect is a symbol or letter, not a picture; it is simply the prefix to the name of a king, and, as such, is placed over the oval ring which surrounds the royal name. Expressed in phonetic characters it is NOU; or, with the semicircular T beneath it, NOUT, as the hieroglyph to the left is SO, or, with the suffix, SOT. Here the com-



Name of an Egyptian king, with the usual prefix. Copied from Mr. Sharpe's work.

bination of a plant and a winged insect represents a king. In a North American tribe, Max Muller† tells us that the conjunction of somewhat similar emblems is employed in a different sense. To the Red Indian mind the figure of a man with a plant for a head, and with two wings, denotes a doctor, skilled in medicine, and endowed with the power of ubiquity.

After Mr. Sharpe's observations it is unnecessary to follow Horapollo any farther. Though it is with some regret that one turns away from all that Aldrovandus ‡ says on the subject, in elucidation of the good qualities of wasps, and of the high appreciation of those qualities by the ancient Egyptians. Horapollo's text, however, it must be acknowledged, does not quite bear out all that his genial commentator builds upon it.

From the Hieroglyphs, in which wasps have only a contingent and divided interest, we turn to the Bible, where these insects are mentioned by name, and a distinct duty § is assigned to them.

* Fig. 288, op. cit.

† "Chips from a German Workshop." Vol. i., p. 318. 1867.

‡ De Animalibus Insectis. Folio. Bononiæ, 1638, p. 220.

§ Exodus xxiii. 28.

The hornet is expressly indicated as a means for slowly driving out the Canaanites before the advance of the Israelites, who were as yet too few in numbers to take full possession of the promised land. The allusions to hornets and wasps, though no more than four altogether, are all to the same effect, and very precise.

There can be no doubt that the hornet was quite equal to the task assigned to her. Whether the expulsion was effected by direct attacks on the people themselves, or by destruction of their cattle or their other means of livelihood, there need be no difficulty in accepting the Scripture statement literally. A much more insignificant insect might have accomplished this quite as effectually; a much less powerful instrument might conceivably have rooted up folks whose ties to house and home were much stronger and more material than were those of the devoted nations.

Apart, however, from the question of whether the insects intended were capable of the task assigned to them, another question arises as to whether hornets were intended at all, whether the word *tsirah* does not mean something different to a hornet. In favour of the correctness of the received text it may be urged that, as hornets were, and still are, very common in Palestine, the authors of the Septuagint translation had every opportunity of being familiar with what they were writing about. So, if they rendered *tsirah* as we read it in our own translation, and selected the hornet as the particular one of all noxious insects to which the word might most properly be applied, we may contentedly acquiesce in their decision. Should any one, however, demur to this conclusion, and wish to exercise his right of private judgment, he will find much further information on the subject in Bochart's "Hierozoicon," * where the question is discussed with great impartiality, and, I may add, at great length. Bochart mentions other interpretations of the word, such as a leprosy or a plague, bodily or mental, but concludes that there is no sufficient reason to doubt the literal accuracy of the received text, and that *tsirah* meant a hornet. It must shake the confidence of any one in Bochart's conclusion to observe that throughout his pages, replete with book-learning and curious items of wasp-lore, the distinctions of natural history are very lightly regarded. It would be too much to expect any distinction to be drawn between different kinds of wasps; but one is scarcely prepared to find wasps and bees confused together, and to see that both alike are supposed to collect honey in their cells. Such, however, and so loose, were the ideas on these matters of many

* Bochart, "Hierozoicon." Ed., Rosenmüller, 4to, Lipsiæ, 1796. Tom. III., cap. xiii. de vespis et crabronibus, pp. 402—417.

of the authors from whom he quotes; and of these ideas he cannot wholly divest himself.

For those who may not care or may not have the opportunity to examine Bochart for themselves, and probably most of my readers would fall under this category, I will, in illustration of this point, reproduce one of his allusions in detail. Later in point of time than the hieroglyphical or Scriptural references, this story is curious as presenting our clients under another, which we will call a mythological, point of view. I do not know of any book in the English language above the range of nursery tales which corresponds to Ovid's "Fasti," by which to measure the amount of authority and credibility which may have been formerly allowed to the narrative. So Ovid shall tell the story, and himself vouch for the accuracy of the facts, both of mythology and of natural history. *

Once upon a time, Bacchus, so the story goes, was returning from his triumphant progress into the East, with his camp-followers, who constituted the greater part of his army, in attendance. Just under Mount Rhodope a swarm of bees were attracted by the cymbals of the Satyrs, and were adroitly hived by Bacchus, who was equal to the occasion, in a hollow tree. The progress must have been quite in the ancient style, for there was time for the bees to build cells and fill them with honey, and for the motley following to learn the taste of honey. The flavour set them all honey-hunting on their own account, and Silenus, the master of the revels, was lucky enough to find a swarm of bees, all to himself, in a hollow tree, where he heard them humming.

We are cautioned by the poet that, though these are in a certain sense serious things,—*Fasti*—we may laugh.

Non habet ingratos fabula nostra jocos.

And he goes on to tell us how Silenus brought his jackass alongside the tree, and, standing on its back, held on by one hand to a branch while he put the other hand in to reach the prize. The result needs no oracle to foretell it. The insects which fly out by thousands are now called *crabrones*, no longer *apes*; but bees or wasps, it is all the same to poor Silenus, whose bald head and shining face are made a pincushion for their stings. The ass, too, gets his share, and, lashing out, deals his astonished master a kick on the knee as he falls headforemost to the ground. The action of the drama now becomes very rapid. The curtain falls amid shrieks of laughter of the Satyrs at the plight of their master, thus punished for his greediness; while

* Ovid, "Fasti," lib., iii., v. 737.

Silenus is limping and roaring for pain; and Bacchus appears at last, the *Deus ex machinâ*, to prescribe Nature's ointment, a good plaster of mud, for his aide-de-camp's face, and a ration of honey all round for the Satyrs. All compressed, as can only be done in Latin verse, into a few lines. Strange that so much nonsense should have clustered round and obscured a few simple facts; that the moral intended in Bacchus, if we take Bacon's* explanation should be actually perverted by the copiousness of illustration, or that the introduction of religious rites from the East, according to modern views,† should be turned into a peg on which to hang stories of how men learned to hive bees and eat honey.

I have already remarked that it is not clear that the insects intended in these early notices were all of them really wasps. The ancients, as a rule, at least those who read and wrote, were not good naturalists. A point of character took their fancy, and dwelt in their memory, more than a point of colour or structure. And they bestowed their names on insects with no more precision than Juliet did on her roses. It is not that the Greeks, to whom I am more particularly alluding just now, were indifferent or incompetent observers of nature, like the modern Brazilians, who call all flowers alike *flores*, and all animals from a fly up to a mule, or an elephant, *bixos*,‡ or that they thought the study of natural history beneath them; but that the knowledge necessary for accurate distinction was not yet in existence. And their thoughts ran in quite another direction. They did not compare trees with trees, and stones with stones, seeking for differences where all seemed alike; but they clothed inanimate objects with life and feeling, and peopled the earth, sea, and sky with beings like themselves. They classed insects, not by their structure, but by their habits, and endowed their familiar animals, in imagination, with the mental characters of their acquaintances. So it is not to be wondered at that there was a special antipathy to our little black and yellow friends, who had no economic properties, like the bees, to recommend them. In the immediate presence of the enemy, probably, then as now, there was no opportunity for discrimination between wasps and bees. But when the danger was over, and became a matter of history or poetry, the stings were put down to the account of the *crabrones*, while the bees got the credit of the music, and the wax and honey.

Bacchus claimed something more than a royalty, the perpetual

* "Wisdom of the Ancients," XXIV. Dionysus, or Bacchus, explained of the Passions.

† Cox, "Tales of Ancient Greece." Introduction, p. xxxii.

‡ Agassiz's "Journey in Brazil," p. 76.

gratitude of mankind, for having discovered the use of the frying-pan, which has been, from that date, a domestic institution in hiving a swarm of bees. But it does not appear that he improved the occasion, by inculcating any rules of caution in handling his favourite insects, nor does any such caution seem to have been habitually observed. Instance the way in which Samson just stepped aside to take some honey from the swarm in the lion's carcase,* and went on eating as if he had done nothing out of the way. The mode of taking wasps' nests, however, was reduced to regular strategic rules by the Greeks. Timolaus† was not above taking an illustration from wasps, when he advised the allies to attack the Lacedæmonians in their own country, on the same principle as they would put a torch to a wasp's nest, before the enemy could get out. Unfortunately his advice was not followed, or the wasp might have become to the Corinthians, what the cicada was to the Athenians, at once their pride and their annoyance.

Euripides ‡ alludes to the same mode of taking wasps' nests in the curious Satyric drama of the Cyclops, suggestively, and as a piece of comic by-play on the part of the Chorus. Homer makes no mention of this use of the blazing torch, in the original draft of the story,§ but the antiquity of the method appears from an indirect allusion in the Psalms.||

The fact of a swarm of bees alighting on the lips of the infant Pindar was hailed as a sign, perhaps a cause, of his future powers. What would a British mamma have thought under the circumstances? Certainly the bees made the most of their time, for cells were run up and filled with honey, actually under Pindar's nose. The omen was certainly auspicious, as it turned out, and no harm happened. But it contrasts with what the Augurs thought of wasps; for the appearance of a swarm of this unpopular insect in the temple of Mars at Capua was regarded as a most alarming occurrence. However, all was done that could be, for not only were the wasps burned, but the magistrates were had out, and a regular form of sacrifice and supplication was gone through to avert the impending calamity.¶

So much for the religious significance of wasps. The bees per-

* Judges xiv. 8, 9.

† Xenophon, "Historia Græca," Lib. IV., § 2, p. 116. Dindorf.

‡ Cyclops, v. 475.

§ Odyssey, IX., v. 382.

|| "They compassed me about like bees; they are quenched as the fire of thorns." Ps. cxviii. 12.

¶ Aldrovandus de Animalibus Insectis. Folio, 1638, p. 220.

haps had as little reason to congratulate themselves personally on their more dignified position, for when the wax and honey were wanted their crown of honour equally ended in smoke. Still they lived afterwards in grateful memory, while quite another epitaph was inscribed upon the tomb of the wasps. They are appointed the guardians of the grave of the ungentle poet Archilochus* by Gætulicus.

ἠρέμα δή παράμειψον ὁδοιπόρε, μὴ ποτέ τοῦδε
κινήσῃς τύμβῳ σφῆκας ἐφεζομένους.

Good traveller beware not to rattle these stones,
Lest you stir up the hornets that swarm round his bones.

And, worse still, Hipponax, another of the *genus irritabile vatum*, was himself poetically transformed into a wasp by Leonidas,† for a similar offence of having stung his rivals to death by his caustic verses.

ἀτρέμα τὸν τύμβον παρτμείβετε, μὴ τὸν ἐν ὕπνῳ
πικρὸν ἐγείρητε σφηκάναπαυόμενον.

Tread light as you journey, and, mind, give his nest
A wide berth, lest you wake the cross wasp from his rest.

If wasps had no fame, they had plenty of notoriety. Aristophanes stigmatizes them in the title of one of his Comedies. There is little in the play bearing on their natural history. They are only brought forwards as apt images of the litigious Dicasts, who lived by bullying and plunder committed under cover of the law. He was indeed aware of the fact that the drones had no sting,‡ but the argument which this fact is made to point is unsound, as the food which drones consume is very small in amount. And the comparison of Philocleon creeping into his house, like a bee or humble-bee with wax—from the tablets—under his nails,§ probably involves an erroneous notion as to the mode of formation of wax.

Aristophanes, in all that he said, did but express the popular notions concerning wasps, and availed himself of an illustration which his hearers could readily appreciate. Why should we blame him in particular for this poetic injustice? The modern wasp was to Shakespere what her ancestor was to the Greek muse, quick and irritable, stinging and making to sting, a robber by taste as well as by trade. It was just the thing for Katharine and Petruchio

* Anthologia Græca, Thackeray. London, 1867, p. 340.
† Quoted from Bochart, "Hierozoicon," Tom. III., p. 414.
‡ Vespæ, v. 1114.
§ Ibid, v. 107.

to bandy words about.* But Shakespere had a deeper feeling than this about our clients, and the thought which his mention of a wasp suggests, on more than one occasion, is expressed in Julia's outburst of pettish anger against her own mischief-making fingers—

> Injurious wasps, to feed on such sweet honey,
> And kill the bees that yield it with your stings.†

Cowper, again, who warmed, like the Ancient Mariner, in his love for animals, caps his opinion of sour old Miss Bridget and her *ἔπεα πτερόεντα*, by an illustration drawn from the same source‡—

> Censorious, and her every word a wasp.

To point a satire or to furnish the sting of a proverb has been the literary use of wasps in all ages. *Quod semper, quod ubique, quod ab omnibus*, must be true; still there is something to be said on the other side of the question.

The wasps which lived before Agamemnon, as we have seen, have no reason to complain of neglect and oblivion. Agamemnon's contemporaries are still better off, embalmed as they are in Homer. Here are no prejudices, nothing to detract from the simple beauty of the comparison; one of Homer's touches of nature sets them before us in all their native restlessness, and their recklessness of danger in defence of their brood, hid, then as now, in holes dug out by the rugged way-side :—

> *ὥς τε σφῆκες μέσον αἰόλοι, ἠὲ μέλισσαι,*
> *οἰκία ποιήσωνται ὁδῷ ἔπι παιπαλοέσσῃ,*
> *οὐδ' ἀπολείπουσιν κοῖλον δόμον, ἀλλὰ μένοντες*
> *ἄνδρας θηρητῆρας, ἀμύνονται περὶ τέκνων.*
>
> "Iliad," xii. 167.

> They're like the many-coloured wasps, or bees by the wayside,
> Making their nests by the dusty road, nor will they relinquish
> Their deep-hollowed hall, but await the assault of their foemen,
> Combating well to the last, for the sake of their home and their offspring.
>
> Simcox's Translation, 8vo, London, 1865.

It is fine to hear the grand old man, as we fancy him, for whose observation nothing was too small. With his harp tuned in the halls of princes, he was not too proud to tell, and to tell exactly, of the ways of Nature's lowliest creatures. He could feel for aught that was noble, and speak of it in the same words, whether it dwelt in the breast of his mighty Hector or in the little body of a wasp. And he had a heart to love all things, both

* "Taming of the Shrew." Act II., Sc. 1.
† "Two Gentlemen of Verona." Act I., Sc. 3.
‡ Table-talk. Truth.

great and small, all, save only the irrepressible small-boys, the Bedouins of all ages, to whom, probably, Homer was then in the body, as now still in the book, a natural enemy.

αὐτίκα δὲ σφήκεσσιν ἐοικότες ἐξεχέοντο
εἰνοδίοις, οὓς παῖδες ἐριδμαίνωσιν ἔθοντες,
αἰεὶ κερτομέοντες, ὁδῷ ἔπι οἰκί' ἔχοντας,
νηπίαχοι· ξυνὸν δὲ κακὸν πολέεσσι τιθεῖσι.
τοὺς δ' εἴπερ παρά τίς τε κιὼν ἄνθρωπος ὁδίτης
κινήσῃ ἀέκων, οἱ δ ἄλκιμον ἦτορ ἔχοντες
πρόσσω πᾶς πέτεται, κὰι ἀμύνει δισι τέκεσσι.
"Iliad," xvi. 259.

Instantly they poured forth like the wasps which dwell by the wayside,
Which, as their custom is, by boys are ever tormented,
For still they vex them as they dwell in their nests by the roadway,
Fools that they are, and a common ill they bring upon many.
Then if some wayfaring man unwittingly move them,
Having, their puny breasts within, a vehement spirit,
One and all, they fly forth enraged, in defence of their young ones.
Simcox's Translation.

The poetry of wasps begins and ends with Homer. However, it is something to have been sung of by the Father of Poetry, and it is still more to have engrossed so much of the attention of the Father of Natural History. Aristotle's knowledge of the habits of wasps was considerable, and contrasts favourably with that of other more familiar animals. Speaking, apparently, from his own observation, he traces the nests from their small beginnings to the point when the mother wasp ceases to build, and confines herself to her strictly maternal duties inside the nest. He describes accurately the position of the egg at one side of the cell, and notices how the grubs at the end of the season are developed into larger wasps—mothers, as he calls them. And following their history through the complete cycle, he tells how, at the end of the season, all the wasps perish, except the females, which are to continue the race during the ensuing year. Mixed with these apparently original observations are various statements, which he thinks it right to reproduce at second-hand without vouching for their accuracy.

The deficiencies in Aristotle's information, are obvious enough to us now, but scarcely more so than they were to himself. He expressly indicates many of the Hymenoptera as forming a natural order, which much needed a name, under which so many insects, having a common resemblance, might be grouped. In particular,

he instances bees, wasps, and ἀνθρῆναι, as having their natural home here. He keeps the bee family distinct, but the ἀνθρῆναι are mixed with the wasps; and though the word is translated *hornets*, it is not certain that these insects were always intended by the term. Not species only, but genera, were involved in a confusion from which it needed years of patient accumulation of observation to extricate them. And he, whose work was so sadly marred by the want of the knowledge which he did so much to supply, felt its need more keenly than any one else.*

Pliny, to whom I must confess that I refer more as a matter of natural history etiquette, than from any respectful consideration of what he has to say on this subject, has a short chapter on wasps and hornets.† But he adds nothing of value to what he adapts, or adopts from Aristotle. He retains, and indeed, rather increases, the confusion about the drones, and he repeats the story of the ichneumon fly, carrying away spiders to lay her eggs in them, with the further improvement that she sits on these spiders to hatch her young.

Doubtless, by a little more irregular reading and hunting in indices, and a little more canvassing of my literary friends, I might be able to lengthen this list of authors, and produce a few more who had something of their own, or of some one else's to say about wasps. But I think that I can claim my reader's willing forgiveness for abstaining from these researches. Passing, therefore, over this period, we come to another, lasting many centuries, during which wasps, like so much else, were trodden under foot unnoticed. Perhaps, the representative men of those ages, who have left their mark so indelibly for good or for bad on that dark period, might have found their own chief characteristics, as great robbers, great melodists, and great builders, reflected in a wasp's nest. It was many centuries before books were written about wasps, such as we write and read, now-a-days. Meanwhile the wasps themselves had been modernized. With the decline of the Roman Empire, a gradual change, though only in name, came over our little friends. The ancient *crabro*, of uncertain etymology, and of the masculine gender, disappeared, to be replaced by the feminine *vespa* of Greek origin. Curiously, *chheka*, the Sanscrit word corresponding

* See Cresswell's translation of "Aristotle's History of Animals." Bohn, London, 1862. The most important passages are p. 127, Book V., chap. 17, § 15; p. 268. Book IX., Chap. 27, § 1, and Chap. 28, §§ 1, et seqq. I have quoted from this as more accessible and more inviting than the original text.

† "Natural History," Book XI., chap. 24 (21). Vol. III., p. 24. Bohn, London, 1855. I quote again from a translation, the only copy at present accessible to me.

to the Greek σφήξ, does not mean a wasp, but a bee; a wasp being represented in Sanscrit by *varatâ*, or *varalâ*.* *Vespa* now appears in one or other guise, in all the chief languages of western Europe, though the Celtic dialects have their separate names for this insect.

With the revival of learning, wasps came in for their share of attention. One or two of these we may notice, commencing with Olaus Magnus,† Bishop of Upsala, who in his retirement from Rome, much like our own Izaak Walton, found a safer occupation in natural history, than in politics, briefly alludes to them in the history of his native country. The description has a special interest to us as probably relating to the species with which we in the north have to do, and it is quite as minute as any one might now-a-days find room for in an account of the Fauna of a country in which he had ceased to reside.

But the type of mediæval naturalists is Aldrovandus,‡ who, like Réaumur, devoted his wealth and leisure to the study of natural history, and in a portion of whose voluminous works the lover of wasp-lore will find some most amusing reading. A first glance at these venerable pages—I quote from quite a typical copy in the library of the College of Physicians, frilled with marginal references, and crowded with quotations—might lead to the conclusion that wasps were a very popular subject with the older writers, and that here was a mine of information on this branch of entomology. But further observation corrects this impression; for the references are numerous rather than various, chiefly to Aristotle and Pliny, with allusions to Nicander and the classic poets, pointed by quotations from Ariosto. And the original observations are few, and so circumstantial, as to suggest the suspicion that the writer was not very practically familiar with his subject. But it would be ungracious to dismiss in these terms a book to which I would confess my obligations, if not as a repertory of original observation, at least as an index where I have re-found all my own references, and found many more besides. Useful on this account, the work is curious also as illustrating a phase in the history of physical science when men played,

* I have the greatest pleasure in acknowledging my obligations here, as on many other occasions, to my learned friend Dr. Greenhill, of Hastings, for an introduction to sources of wasp-lore, which, but for his kind and able assistance, would have been closed to me.

† Historia de Gentibus Septentrionalibus, etc. Folio, Basiliæ, 1567. Lib. XXII capp. 3, 4.

‡ Ulysses Aldrovandus de Animalibus Insectis. Libri, VII. Folio, Bononiæ, 1638. Lib. I., capp. 6, 7, de Vespis et Crabronibus. The entire work runs to 13 folio volumes.

as it were, with the statements of the older writers instead of confirming or correcting them by recurring to the observation of Nature. It was not the *Hippocrates ait—Galenus negat* of the schools, but Galen and Hippocrates were jumbled up together, and everything that everybody had said was reproduced till the fact was quite put out of sight by the multitude of the authorities, the wood by the trees.

One more author of this period, though scarcely a typical one, claims attention here. The versatile genius of Porta,* to whom we owe the invention of the camera-obscura, was for a passing moment turned to natural history, but only to add the weight of his name to the statement of half-a-dozen older authors that wasps were generated from the carcase of a horse. This belief of former ages neatly expressed by Nicander†—

ἵπποι γὰρ σφήκων γένεσις ταῦροι δὲ μελισσῶν

he reduces to a formula, by the aid of which any one may produce a swarm of bees, within a given number of days. Had Porta interrogated Nature herself in this matter, the asserted origin of such perfect creatures as bees and wasps in the decomposition of animal substances would scarcely have been recognized as a fact of natural magic.

In a few years' time a change came over the study of natural history. The book of Nature now took precedence of all others. The scholastic incrustation which incumbered every topic which had been mentioned, however casually, by any writer of note, was swept away, and the path was re-opened by which all subsequent observers have travelled.

I cannot be far wrong in selecting Swammerdam as a representative of the class of naturalists who took up the work where Aristotle had left it. There is something in the title of his work suggestive of the spirit in which it was written.‡ Wasps, however, it must be owned, obtain but scant notice from him, and the descriptions are almost exclusively comparative, in illustration of the habits and structure of his favourite bees. The longest and most particular description is of the tongue of the wasp, and the

* Porta, J. B., "Magia Naturalis," 24mo. Lugd., Batav., 1650, p. 53. Contrast with this book its modern representative, "Letters on Natural Magic," by Sir D. Brewster. Small 8vo. London, 1833.

† Quoted from Aldrovandus, op. cit., p. 228. Nicander is cited by Cicero, De Oratore, Lib. I. Cap 16, as having written on agriculture, as Aratus did on astronomy *præclare*, though both alike were practically unacquainted with what they were writing about.

‡ "Bybel der Natuur." Folio, Leyden, 1737.

occasion of introducing it is characteristic. He scarcely thinks that the lapping mechanism of the tongue, which he denies the existence of in the bee, would be sufficient to satisfy the requirements of wasps,* "Cum rapaces admodum, truculentæ, atque avidissimæ sint Bestiolæ," and concludes that they must employ some other method of taking in food besides that which the form of the tongue suggests. The poor wasps have no share in the note of general pious admiration which the mention of the honey-bee evokes in every page.

Limited in the choice of authors to a few well-known and accessible volumes, still I have no doubt in adopting Réaumur † as the representative of a still later and more advanced stage of modern Natural history as applied to our particular subject. A wider choice might supplement, but could scarcely replace these interesting volumes. We feel at once among our friends—the wasps—of this season. There is nothing in the pages of Réaumur to indicate that he wrote so many years ago. The descriptions and figures are true to Nature now as then, and we need the old-fashioned vignettes of the quarto to remind us that these observations were not made by one who lived and dressed like us, but in the fresh recollection of the times of the Grand Monarque.

The honey-bee had the foremost place in Réaumur's as in Swammerdam's affections, and the wasp is introduced with an almost apologetic preface, as the natural enemy of the bees which have been just before described. Two memoirs are then devoted to a systematic account of wasps and their works,‡ in which the chief features of their natural history are sketched with great care and skill. The distinction between wasps and bees is drawn from the old classical character of the narrow waist, the black and yellow or orange livery, the short and square tongue, and the habit of folding the wings during rest, peculiar to the family of wasps both solitary and social. He describes from personal observation, both on wild and imprisoned swarms, the mode of making and laying on the paper of which the nest is composed, and, with some doubt as to the correctness of the results, from the difficulty of observing all the circumstances accurately, he calculates the time required to develope an egg into a perfect wasp. A nest of *Polistes* and a small hornet's nest, which last he transferred to a situation

* Op. cit., vol. i., p. 451. Gaubius, in his Latin translation, fully conveys the *animus* of the original, but less generally intelligible, Dutch.

† "Mémoires pour servir à l'Histoire des Insectes." 6 Tomes, 4to, Paris, 1734—42.

‡ Op. cit. Tome vi. Memoires 6 et 7.

convenient for observation, supplied more accurate data for his inquiry, but the same accident befell his tame hornets as subsequently both Pastor Muller's * and Mr. Newport's,† the swarm languished and failed after the loss of the queen.

Each page of this narrative tells of the exercise of the most constant varied observation. The habit of the insects, their gentleness to those who would handle them properly, their mode of feeding their young, and the difficulty of bringing wasps up by hand, with many little points of difference in the arrangement of various nests, all are duly noted. The nocturnal habits of hornets, which cost him his queen, the symmetry of their comb depending from a larger central column, and the coarseness of the paper, are set before us as freshly as if only written yesterday; though an economist might deem the suggestion of importing from Cayenne the materials of which the card-board wasps make their nest, a little out of date, and not a little visionary.

The distinction of sex, as far as was then known, is clearly laid down and illustrated by careful microscopic drawings; and if the microscopic anatomy of wasps occupies so small a space in their history, we can hardly be surprised when we consider with what difficulties this branch of inquiry was beset in Réaumur's time. But the want of proper optical appliances was scarcely so great a stumbling-block as the want of proper distinctions of species. Seeing farther than Aristotle, Réaumur demurred to his opinion, that the cause of wasps building in high places, was the loss of their ruler. But he does not explicitly refer this habit to a difference of species, nor does he describe what really does happen when the wasps have lost their rulers.

De Geer closely follows on the track of Réaumur, in a work of the same title,‡ and on a similar plan. As Réaumur had made his observations on ground-wasps, so De Geer turned his attention to the species which build in trees or under eaves. His descriptions lack the fresh interest which we find in Réaumur, but this is due, in a great measure, to the care with which De Geer has constructed his narrative, supplementing, not reiterating the observations which had as great a charm for him as they have had for all other naturalists since his time. Here are more or less exact descriptions of three kinds of wasps. The small wasp needs little more to

* Magazin der Entomologie. Germar. Halle, 1817. Band III., s. 56; Band III., s. 56.

† Trans. Entomological Society of London. Vol. III., 1841-43, p. 183.

‡ "Mémoires pour servir à l'histoire des Insectes." 4to. Stockholm, 1752—1778. Tome II., Partie 2nde, Memoire 13me.

be said to establish it as *V. Britannica*; and the importance of the form of the male sexual organs is insisted on, as at once showing that we are dealing with a different species to Réaumur's ground-wasps. His middle-sized hornet appears distinctly to be *V. media*, a species not known in these islands. And the third species is the familiar ubiquitous hornet, drawn with unmistakable accuracy.

If the mode in which De Geer tells his story, and the generous way in which he limits his subject, detract from the interest of his work, they add much to its usefulness. Omitting all such topics as he deems to have been fully illustrated, he never fails to throw the light of his better knowledge on any point to which he addresses himself. If Réaumur was the first truly modern writer on this subject, De Geer was the first to show how to profit by such a master.

He dwells on the notched outline of the compound eyes, as a character distinguishing wasps from bees; he describes the locking of the wings in action, and their folding in repose, and while he improves on Réaumur's account of the teeth, he denies the accuracy of his description of the form of the opening of the mouth. Speaking from his own experience, he evidently thinks, and all will probably agree with him, that Réaumur greatly overestimated the number of wasps in a swarm.

Though our knowledge of the natural history of wasps has been much advanced since Réaumur wrote, there can scarcely be said to be any work which constitutes an epoch in the subject, since his time. Perhaps Kirby and Spence's work, which has done more than any other work to popularize entomology, may seem an exception to this statement. But it is not really so. They stand on the same ground as Réaumur, the popularity of their work is due to the same fresh truthful observation of Nature, and the form in which their work is cast, to which, indeed, a good deal of its popularity is owing, tends to keep out of sight much of the direct advance of entomology since Réaumur's time. How all this knowledge grew up and was put together, it would exceed my present limits to say, and I would not willingly deter any one from the study of a most interesting subject by a display of names, which he could easily procure for himself, whenever he may need the information.*

* Westwood "On the Modern Classification of Insects," vol. ii. p. 236, gives a list of authors on the Diploteryga, to which may be added the foot notes and textual references in the particular description of the Vespidæ, p. 244. It might be thought superfluous to mention other books to any one who has Hagen's admirable Bibliotheca Entomologica, 8vo, Leipzic, 1862, to refer to. But De Saussure's "Etudes sur la Famille des Vespides," 3 Tomes, 8vo, Paris, 1852—58, has claims to the student of this subject which should not be taken at second-hand.

The natural history of wasps, it is needless to say, is not co-extensive with entomology generally, and I fear lest I should seem to have given them a longer notice than they can fairly claim. Yet I must plead that much entomological knowledge has been obtained by the study of the structure and habits of the Hymenoptera, and that the hornet—in her own way—deserves as well of science as the frog. And if wasps have always stood in the cold shade of the bee, at least there is a stamp of earnestness on all that has been written about them, and an entire want of that gasconading which occupies so much of bee-literature. And yet another recommendation to busy men who take up entomology as a pastime, the literature of wasps, however fragmentary, is much more compendious than that of their popular cousins.

The history which began with a few scarcely intelligible scratches on an Egyptian monument, has expanded, at the present time, into an account as circumstantial as many animals standing much higher in general esteem than wasps can boast of. We recognize now in the wasps a large well-defined family of the Hymenoptera. They shade on one hand into the bees, from which they are chiefly distinguished by the arrangement of the nervures of the wings, the narrow tibia, the form of the tongue, and of the compound eyes. On the other hand they are separated from the sand-wasps by less distinct characters, both of habit and structure. Though we do not feel this indistinctness in our British classification, the only intruder among our *Vespidæ*, breaking the sharp outlines by which the *Vespæ* are defined, being our harmless unnoticed *Odyneri*. The mention of a wasp to us in England, recalls the idea of a smooth yellow or orange insect striped with black, with a square short tongue, thin legs, a pinched-in waist, and a sharp sting. And the narrow space into which its wings are folded in repose, must have struck many of those who were unaware of the distinctive importance of this habit.

The *Vespæ*, the typical family, make their nests of paper, with the case separate from the horizontal combs. Though, on this point, there is considerable difference in the different families of Vespidæ, yet, for each, its rule is so strictly maintained, that the relation of the case to the comb, the direction of the central axis of the nest, the form and material, to the minutest detail, have been made the basis of a method of classification of social wasps. But, however much the general form of the comb or case may differ, the cells are always strictly hexagonal, and, built as they are of a stiff unyielding

substance, we must take their form as a result of the instinct of the individual, not as an incidental effect of the combined work of many labourers.

They are divided, like bees, into males, females, and neuters, which last, since Réaumur wrote, have been shown to be abortive females. Their nest is the work of a single season, the colony beginning with the queen, who is impregnated in the previous autumn, and survives the winter to lay the foundation of the paper-city. The whole well-being of the community turns on the queen-mother, and her loss is absolutely irreparable. Unlike the queen-bee, who can be reproduced, not by a breath exactly, but by good feeding. The singular law of Parthenogenesis, by which abortive or unimpregnated females can lay male eggs, obtains among wasps, as among bees.

Wasps are no respecters of persons, it is only our knowledge of them and their habits, that gives us power over them. Much as I have handled them, I never venture to approach them without caution, or to neglect such means of defence as are adapted to the probable amount of disturbance I am about to cause. At least, however, they are not capricious, and they only give blow for blow. The happy owner of an active wasps' nest, may extract much scientific interest out of it, but no sentiment, and no honey worth the having. Wax of course is out of the question, and the honey which some wasps are said to collect, is, judging from the production of *Nectarinia*, a nasty mixture of pollen granules and honey which they have stolen from the bees and put away, for a more convenient season, in their cells. The scientific interest of a wasps' nest, however, is far greater than that of a bee-hive; as the movements of wasps are more easily directed, and more readily intelligible, than those of honey-bees.

The title of this paper suggests a question, which it seems most convenient to discuss here, namely, whether the species of wasps which we see, and sometimes feel, now-a-days, are identical with those of ancient times? whether Homer and Aristophanes took their ideas from the same wasps as supply images to modern poets? This is a question to which perhaps no positive answer can be given. However, in the absence of any direct information, we may reasonably infer that the species of wasps have not changed within the period of Man's knowledge. For, during these few hundred or thousand years, there have been no considerable changes in the external conditions on which the well-being of wasps

depend, by which such mutation of species could have been effected, or to which wasps might have adapted themselves. For rugged ground, rotten trees, garbage, fruit, and insects, all the ways and means of wasps, have certainly been available for them ever since Man could describe what he saw around him. The varieties, indeed, which we notice in collecting the Fauna of different countries, show that the laws of mutation which have affected the species of other animals, have equally affected those of wasps; but within human knowledge, in the cycles counted by the historian, not by the geologist, there is no reason for asserting that any change has taken place. And all that has been said of the classical wasps of ancient times, may be applied to our own, saving always the difference between Monmouth and Macedon, between Greek and English wasps.

There are seven kinds of wasps indigenous to these islands which seem fairly established as distinct species. The varieties within the limits of some of these species are, however, considerable in Great Britain, and the variation is still greater in some Continental specimens. At the risk of being tedious I must notice some of these more particularly.

V. sylvestris, so variable in her habits that it is questionable whether she should be regarded as a tree or a ground wasp, is singularly uniform in her markings. But *V. rufa* presents such various forms and tints in different broods, that none but close observers could be sure of the identity of the species in them all. Only by such careful observation is *V. arborea* to be discriminated from *V. rufa*. The difficulty is greater still in the case of *V. germanica* and *V. vulgaris*, which vary into each other's markings, the variation of the former being chiefly by increase, that of the latter species by diminution of the markings. As a matter of fact the exact distinction between these two rests not on any outward markings but on differences of the internal structure of the males of the two species respectively. A very large nest of *V. germanica*, which a friend kindly brought me from Madeira in 1865, had all the wasps marked in a very peculiar manner, the type of the markings tending strongly to that of *V. vulgaris* in both sexes, in the abortive as well as in the perfect females.

But the occurrence of the same markings in specimens of *V. germanica* from Mentone, prevents the inference that the Madeira wasps were in process of development into a species peculiar to that island. Again *V. britannica* varies very much in different broods, the lateral orange spots being well marked in one, while

they are scarcely to be seen in another. But the nearest approach to a fixed variety seems to occur in *V. Crabro* where there are two distinct types of external marking, one kind cloudy, very exactly resembling the markings of *V. vulgaris*, the other with hard outlines and narrower. Still as these distinctions of colour are unconnected with difference of habit, and, as far as I have seen, difference of internal structure, they cannot claim the importance of specific distinctions.

To the question how far are these distinctions hereditary? I can return no answer. A season devoted to the study of wasps, in a demesne from which all animals injurious to wasps, and especially little boys, were rigidly excluded, might probably show how far the characters of the mother were impressed on her brood. But, such as wasps are, I could scarcely anticipate any satisfactory results, even with all these advantages, from an attempt to carry this inquiry over a second year, into the next generation. Wasps are manageable enough when they have given hostages to fortune in the form of houses and children, but it is as impracticable to make a wild wasp build, as to make a polypody grow in confinement, and when once a wasp has left the nest, she is lost to observation.

I suppose that it will be generally conceded, by those who have considered the subject, that the various species of animals and plants which occupy different countries are fixed varieties, which have grown up in the lapse of ages, adapted to the various circumstances of the countries in which these animals and plants have been placed. But how they grew up, whether the mutation of species was under the guidance of natural selection, or of some other influence for which we have no name, and of which we have no precise idea, observers are by no means so universally agreed. And a great deal of feeling, which has nothing whatever to do with the question, has been introduced into the discussion.

I have neither the knowledge or the leisure to enter into the question here, nor do the social Hymenoptera furnish the ground which an advocate of the mutation of species by external influences would willingly take his stand on. Their history, indeed, supplies some of the most formidable objections to this theory, aud one of these is notably the relation of the workers to the rest of the swarm. The workers do all or nearly all the work; all the qualities which are beneficial to the race are centred in them, all the capacities of the race are tested in them. Yet these workers are only the barren recipients of excellences which their own good qualities have not evoked, and which they are incapable of trans-

mitting. Again; the adaptation of a common larva to the condition of a queen-bee by change of position and nourishment, while it shows what can be done by external influences in this direction, shows how very limited the effects are. For when the results of these preparations are to be worked out, at the very moment of projection, the embryo is most carefully sealed up, in order that the powers which it has within itself may work without any hindrance from external interference. What happens to the embryo of the bee happens to the embryo of all animals; the materials may be supplied from without, but the directing power which disposes of all these materials comes from within. And beyond the external supply of materials, and the internal force which disposes of them, there is another influence, for which we have not a name, which adapts the progressive changes of the embryo to conditions with which it is wholly unconnected. Under such guidance are the preparations of the embryo for extra-uterine life. Such, more remotely, are the adaptations of the chrysalis for its evolutions exactly at the time when the series of arrangements for the sustenance and reproduction of the perfect insect are completed. And such a relation, though it be less obvious, I believe to exist between all created beings in process of development and the places they are to occupy in creation. Else, considering the long period that is required for the development of a new, or the modification of an established form, by the time that the zoological changes were completed, the external conditions to which they were adapted might have passed away, and the change would have been all in vain, hopelessly futile after countless ages.

It is quite as consistent with all that we know of the attributes of our Creator to suppose that He endowed all creatures in the first instance, with a power of adapting themselves to all the varying circumstances of the world in which He placed them, as that He created them in all their different varieties in each different place, and still creates them anew as may be required. We are at liberty to suppose either case, for we know nothing about it; they are both equally possible, equally consistent; but Science shows the former to be the most probable. On the farther question, whether the power of adaptation has been left entirely to the creatures themselves, or whether a constant directing influence is exercised over them, Science has nothing to say, and we must be guided by the analogy of God's government of the world, as far as we can trace it, in drawing our inference.

Only one word more in conclusion. The most probable result

of all the living occupants of the world striving independently after their individual advantage, seems to me illustrated in the result of the mutual attrition of the pebbles on the beach. I see no sufficient reason to discard such phrases as a place in the Scheme of Nature or in the Scale of Creation. Admitting fully the existence and action of faculties in all the different living creatures by which to adapt themselves to their several places, I cannot but recognize in all this the Hand which made both them and their places, and draws them there. And holding the one opinion to be just as tenable as the other, from a scientific point of view, I prefer the belief in a constant superintending benevolence to that which is expressed in the terms of the Battle of Life and the Struggle for Existence.

COAL-TAR AND ITS PRODUCTS.

BY EDMUND J. MILLS, D.SC., F.C.S.

(*Continued.*)

In the course of the two preceding articles, allusion has been made to the most prominent of the coal-tar colours which are prepared from non-nitrogenous bodies. We have now to take a brief survey of the much more extensive and still more important territory occupied by the colours that contain nitrogen. These have been long known by the somewhat incorrect name of aniline dyes.

It has been already pointed out that aniline is prepared by reducing nitro-benzol with iron and hydric acetate, and that nitro-benzol is produced by the action of hydric nitrate on benzol, which is contained in considerable quantity in common tar. Now, although these transformations have been known to chemists for many years, aniline and its derivatives remained but laboratory curiosities until the year 1856, when they were first recognized as practical sources of dyeing material. It was in that year that Perkin endeavoured to turn the theory of compound ammonias to profitable account, by preparing quinine from a derivative of toluidine. This object will no doubt be realized, sooner or later, in connection with coal-tar, and probably in some altogether unexpected manner, as we have seen was the case with alizarin. Perkin failed in his attempt; instead of obtaining quinine, a "dirty reddish brown precipitate" was the result. Anxious to know more of the reaction, he then pro-

ceeded to examine the behaviour of aniline (a more simple, but analogous body) under the influence of the same oxidising process. The black precipitate thus produced appeared sufficiently unpromising in the aqueous solution from which it had separated; but, when moistened with alcohol, it yielded a magnificent purple solution, which proved, on investigation, to contain a new and very remarkable tinctorial agent, now familiarly known as *Mauve*. This was the starting-point of a new industry. Mauve is the product of a comparatively simple operation. A cold solution of aniline in water containing oil of vitriol is mixed with the proper quantity of dissolved potassic dichromate, which, under such circumstances, is capable of producing powerful oxidising effects. The general character of the chemical change thus brought about is that of oxidation; but its particular course has not been satisfactorily traced, the new substance, *mauveine*, having no clear symbolic relation to aniline, from which it is derived.

C_6H_7N	$C_{27}H_{24}N_4$
Aniline.	Mauveine.

The purification of crude mauve is effected by washing with water, extracting several resinous matters with naphtha, and then dissolving in alcohol; the alcoholic solution, when evaporated, yields mauveine in a sufficiently pure state for commercial purposes. Perfect purity is attained by solution in a very large quantity of water, filtration, and precipitation with an alkali, followed by repeated washing with water and the alcohol treatment already mentioned. Mauveine is then left as a black lustrous residue, not unlike specular iron ore. Several of its salts are crystalline, the acetate and hydrochloride exhibiting a beautiful green reflection on the face of the crystals. They dissolve in strong oil of vitriol, forming a green solution which becomes blue when diluted, and in which the colouring matter continues unimpaired. Aqueous hydric chloride behaves in a similar manner; but ammonic hydrosulphide gives rise to a pale brownish tint.

The preparation of mauve is attended with considerable loss of aniline, which is to a great extent converted into brown resinous materials of no tinctorial or commercial value. On the other hand, mauve is most easily and economically applicable to dyeing purposes. All that is necessary is, to immerse the silk or woollen fabric in a weak alcoholic solution until the desired shade of colour has been obtained. So great is the attraction of silk and wool for the colouring matter, that the solvent can thus be decolourized entirely. Mauve, however, does not combine with cotton. Hence, if a mixed silk and cotton

tissue be immersed in its solution and then washed with water, the cotton retains its original appearance, while the silk is dyed. Magenta, picric acid, and other coal-tar colours, behave in a similar manner. Mauve can easily be fixed in cotton which has been previously mordanted with stannic hydrate and soaked in a watery solution of tannin; or, it may be mixed with albumen in the cold, printed on the fabric, and fixed by means of steam.

Mauve is a very stable colour, and resists the action of light to a very considerable extent. Attempts have been made to constitute it a source of new colours, more especially a blue and a grey; but they have not been commercially successful.

The history of *Magenta,* which rejoices in more synonyms than were ever possessed by any other tinctorial agent, having been termed fuchsine, azaleine, Solferino, roseine, rosaniline, etc., etc.,—is of a somewhat different character from that of mauve. The latter colour had acted the important part of a pioneer, and, among other incidental benefits, had accomplished the preparation of aniline itself on a manufacturing scale. General attention had been directed to aniline by Perkin's discovery, and it was not long before it proved capable of yielding a red pigment. So far back as 1843, Hofmann had noticed the red coloration produced when hydric nitrate acts on aniline, and it was again observed by Natanson in 1856, when investigating the behaviour of aniline towards ethylenic chloride. In 1858, Hofmann had recognized its specific existence and its basic properties; and, at the commencement of the next year, Messrs. Verguin, and Renard Brothers, of Lyons, took out patents for the manufacture of aniline red by acting on aniline with stannic chloride (chloride of tin). It was not long before the nature of the obscure chemical change which took place was sufficiently guessed at to enable a number of successful experiments to be made for producing the colour in different ways; and the number of unsuccessful patents taken out at about the same time was proportionately large. As it was known that industry was now willing to confer on investigators some of the greatest monetary rewards reaped by chemists since the time of Paracelsus, a somewhat keen, and not always creditable, competition was the result. Patents were taken out for the preparation of magenta by means of substances which were in many cases quite incapable of yielding it, and were as often ill suited to the purpose. A few really useful processes stood the test of time; but the one which effects the desired object most cheaply and effectively is that of Medlock. This consists in heating aniline with rather less arsenic acid than is sufficient to combine with it chemi-

cally, to a temperature not exceeding 160° C. A somewhat violent reaction occurs, accompanied with much intumescence, and, at the end of from four to nine hours, the transformation is complete. The product is cooled, when it becomes brittle and bronze-like; it is purified by alternate treatment with hydric chloride and caustic soda, with the assistance of filtration. It will be observed that while magenta and mauve are both formed by an oxidising process, that the conditions are respectively very different; mauve requiring a slight excess of some acid body and a considerable amount of water, while magenta requires a slight excess of aniline, and the presence of even a little water is unessential.

On account of the early difficulties in the preparation of perfectly pure magenta, and the great obstacles which stood in the way of its preparation in the laboratory, it was some time before the exact nature of this remarkable pigment was elucidated. The most conflicting statements were made respecting it; and, at one time, its colour seemed to be almost the only point on which chemists were agreed. It was called acid by some, basic by others; it was said to contain oxygen, and to contain no oxygen. Improvements, however, gradually took place in the manufacture, and at length Hofmann, with valuable supplies of pure material obtained from Messrs. Simpson, Maule, and Nicholson, commenced its investigation.

Magenta, like mauve, is a general commercial name for a basic body and its saline compounds. Hofmann has given to the basic body, in this case, the name of *rosaniline;* and its formula is $C_{20} H_{19} N_3$. Rosaniline itself is quite destitute of colour, but as soon as it comes in contact with any acid substance (vinegar, for instance, or even the air) coloration takes place with greater or less rapidity. In its general behaviour with the ordinary reagents, rosaniline closely resembles mauveine. There is but little loss of aniline in its preparation.

The salts of rosaniline are, for the most part, easy to crystallize and of great beauty. The hydrochloride ($C_{20} H_{19} N_3$, H C Z) and its analogues exhibit the magnificent green reflection of the wings of certain beetles; by transmitted light they appear red. Chevreul finds that the green colour reflected from the crystals is complementary to the well-known tint which their solution imparts to wool and silk. That this difference should exist at all, is probably due to the transition from the compact state of the crystal to the fine division of the powder which is spread upon a tissue by dyeing. Striking illustrations of the truth of this explanation are very common in chemistry. Gold, for example, when very finely comminuted,

is a purple powder, but yellow in a mass of considerable dimensions. Tannate of rosaniline has a beautiful carmine tint, comparable with that obtained from cochineal; it is an insoluble powder.

Hofmann's investigations naturally led him to inquire into the relation of rosaniline to aniline. The formula which he had found, though less complex than that of mauveine, resembled it in bearing no very obvious relation to the parent substance. Nicholson had already remarked that certain specimens of aniline were incapable of furnishing the colour, and Hofmann now found that pure aniline, from whatever source obtained, yielded no rosaniline when appropriately treated. At first it was conjectured that the formation of this colour might be due to traces of an "isomeric" or twin aniline, whose existence had been rendered probable by Church. Toluidine —a substance which, as pointed out in the last article, is contained in all commercial aniline—was likewise found to yield no rosaniline. But when a *mixture* of pure aniline and pure toluidine was used, arsenic acid immediately developed the splendid coloration characteristic of rosaniline; hence toluidine is a necessary element in the theoretical interpretation of the reaction. No satisfactory equation can, however, be given to represent the whole of what occurs; for, in addition to rosaniline, small quantities of other tinctorial or resinous matter are simultaneously produced, and their exact nature has not yet been made out.

Silk and wool are dyed by mere immersion in a solution of rosaniline salt. The liquid has to be diluted considerably, on account of the extraordinary violence with which those substances abstract its colour. When we reflect upon the meaning of this fact, namely, that silk and wool are capable of removing rosaniline from even its most stable combinations, we are compelled to assign them an acid character, of an intrinsic energy superior to that of hydric chloride, or hydric sulphate. Cotton, on the other hand, requires the use of mordants.

One of the impurities in commercial magenta, which sometimes interferes considerably with its proper tints, is *chrysaniline* ($C_{20}H_{17}N_3$), a less highly hydrogenated basic substance than rosaniline. Both it and its salts dye silk of a beautiful golden yellow, but it has not come into very general use, inasmuch as being only a by-product, and not occurring in large quantity, it is comparatively expensive. In commerce it is said to be known as Victoria Orange.

The discovery of magenta was soon followed by the preparation of another dye of nearly equal importance, in which magenta itself

was made the starting point instead of aniline. Early in 1861, Girard and De Laire published their process for preparing aniline blue, or, as it has been termed, "bleu de Paris" and "bleu de Lyon." In order to obtain the new product, it was merely necessary to heat a salt of rosaniline with excess of aniline to 160° for a few hours; gaseous ammonia was given off, and aniline blue left behind. In the solid state, the new pigment presents a copper-coloured reflection, without any admixture of green. Its general deportment is very similar to that of the other aniline colours. Hofmann, to whom the chemistry of aniline and its derivatives is so greatly indebted, commenced the investigation of aniline blue as soon as it had begun to be manufactured here on the large scale and in the pure state. The clue to its nature and mode of formation was comparatively easy to find. Aniline blue is rosaniline in which a constant proportion (three nineteenths) of the hydrogen has been exchanged for phenyl ($C_6 H_5$), a substance to which I have already alluded in connection with benzol. The following comparison will render this relation more clear.

$C_{20} H_{16} H_3 N_3$	$C_{20} H_{16} (C_6 H_5)_3 N_3$
Rosaniline.	Triphenylic Rosaniline.

This was an important result, for the theory of compound ammonias points at once from this to the certainty of obtaining an endless series of new colours of the same general type, but of every variety of shade. Here is a fresh instance of the utility of the pursuit of abstract research; the theory in question had been elaborated and settled several years previously, but altogether regardless of any application which commercial people are apt to consider *practical.*

Common spirit of wine is, when pure, a definite chemical compound, in many respects analogous to potash (potassic hydrate). When considered from that point of view, it is accordingly termed *ethylic* hydrate; for, just as potassium can be prepared from potash, so can ethyl be prepared from common alcohol. There are, moreover, very many substances sharing alcoholic functions; wood spirit consists chiefly of methylic alcohol, distillers' "faints" of amylic alcohol, carbolic acid of phenylic alcohol. Again, just as potassium is capable of forming an iodide (potassic iodide), so also do ethylic, methylic, amylic and other iodides exist. Now Hofmann, by acting on rosaniline with these iodides, succeeded in preparing triethylic, trimethylic, and triamylic rosaniline, all of which are strictly analogous to triphenylic rosaniline.

Triethylic rosaniline is a very rich and bright violet, and is

extensively used. Trimethylic rosaniline resembles it very closely, but has a decidedly bluer shade. There exists also a tritolylic rosaniline, which is very similar to ordinary aniline blue, but more soluble.

The fact that magenta, on heating with aniline, yields ammonia and aniline blue, has led to the treatment of a salt of aniline itself with aniline. Here also ammonia is found to be given off, and a salt of diphenylamine is formed, which it readily transformed into a blue by oxidising agents. This reaction has, indeed, proved to be a very fruitful source of colour, and is capable of almost exhaustless variation. Mauve and magenta undoubtedly constitute the most important of the aniline colours, whether we consider them merely in themselves, or as the actual or possible sources of new tinctorial substances. They are also the best investigated of the aniline colours. The theory of those we are now about to describe is more obscure; but they furnish great illustrations of the many-sided applicability of aniline and toluidine.

Aniline green has been manufactured for about six years. It is prepared by dissolving purified magenta in slightly diluted oil of vitriol, and heating it for some time to 100° C. with a considerable proportion of aldehyde. Aldehyde is a powerful reducing or deoxidising agent, yet its effects under the above conditions are much more energetic than could have been anticipated. It is the first substance of its kind that we have had occasion to notice in the course of this history. When the mixture has been heated sufficiently it is treated either with sodic sulphide or with sulphuretted hydrogen water, to which hydric sulphite is afterwards added; or with sodic hypo-sulphite, the well known fixing salt of the photographers. A green liquid is then formed, which requires to be used at once, as the colour is very liable to alter; a precipitate is simultaneously thrown down, which has a greyish blue tint, and is used in dyeing, under the name of argentine. Aniline green is very commonly prepared by the dyer as it is wanted. The materials employed in its preparation render it rather expensive. It has been proposed to make a green by a peculiar method of oxidising aniline; but the process does not seem to have ever attained any commercial importance. Another aniline green has been made by using excess of ethylic iodide in the preparation of Hofmann's violet; a considerable yield of the former colour is then obtained, and is easily freed from violet by digesting the crude product with a weak aqueous solution of sodic carbonate, when the green alone dissolves. It is said to be preferable to aldehyde green. Lastly, a

mixture of aniline blue with picric acid has been employed as a green; but the result is very unsatisfactory in artificial light.

Aniline black, discovered in 1862, is somewhat connected with aniline blue by its mode of formation. It is not, however, a true black, but an extremely dark blue or green, having a rich velvety aspect. A disputed point in relation to this substance is, whether copper is or is not one of its essential constituents, or at least necessary to its formation. This black is not used as such, but is developed in a tissue, on which it is printed in the state of paste. This paste essentially consists of cupric sulphide, potassic chlorate as an oxidiser, and hydrochloride of aniline; the colour is developed at about 30° C., and the fabric can be washed after a day's interval. Other copper salts have been used, and receipts have been proposed in which no copper compound appears. In the former case, the paste rapidly becomes so acid as to act most injuriously on the iron rollers as well as on the tissue; in the latter, it is said that no black is obtainable unless copper or bronze rollers be employed. On the whole it seems probable that a copper compound is required as the incentive to some special modification of the oxidising process, but that it is not a necessary constituent of the colour.

Aniline black is the most stable of all the coal-tar colours. When once fixed on a fabric it resists every effort to remove it. Strong acids and alkalies, powerful oxidising agents, alcohol, ether, naphtha, soap, are without serious effect upon it. Even when partially bleached by the continued action of chloride of lime, the original colour gradually reappears on washing and exposure.

Aniline brown and maroon are products of the same kind of oxidation as that whereby aniline black is prepared, only that it is less intense. Thus, for example, a solution of magenta, when treated with potassic chlorate and hydric chloride, yields Kœchlin's brown as a precipitate, which is soluble in alcohol and sulphuric acid, but insoluble in water. It is fixed on cotton by means of albumen. An excellent maroon is obtained by boiling a mixture of hydrochloride of aniline with one-fourth of its weight of hydrochloride of rosaniline, until the mass suddenly changes to the desired tint. This colour is soluble in alcohol, ether, benzol and acetic acid, but is precipitated by saline solutions. The shades it yields on silk and leather are very satisfactory.

It has been already stated that the formation of what is termed an aniline colour is by no means a simple chemical change, and that in most cases, we are still ignorant of the details of what occurs. Each colour has to be purified from some other, which accompanies

it in varying quantity, and is an index of a complex transformation. The amount of toluidine which theory indicates as a necessary addition to aniline in the preparation of magenta, is considerably in excess of the practical quantity. Still, there are some general results which appear to be sufficiently demonstrated to be worthy of notice. There can be no doubt, for example, that all these colours are of a much more compound nature than the parent substances, and that the effect of direct oxidation is to combine aniline with itself and more or less toluidine, with simultaneous subtraction of hydrogen, and perhaps carbon and nitrogen, in some simple forms. In the case of mauveine, carbon seems certainly to have been lost. Derivatives of the colours are obtained, with new tints, by exchanging the hydrogen of a ready-formed colour for what is termed an "organic radical," such as phenyl, methyl, ethyl; and this process is, of course, attended with the production of substances whose formulæ are increasingly complex, although the chemical change therein involved is not complex.

A casual perusal of the chemical literature of colours might lead to the conjecture that colour and complexity—the kind of complexity that can be indicated in a formula—go hand in hand. Guesses of this kind, however, invariably ignore the doctrine of plurality of causes, and this particular one is encountered by a variety of adverse facts. The group of "fatty" bodies, for instance, or substances more or less intimately related to common alcohol, is very familiar to chemists, having been the subject of most intimate study. Several of its series are known, in which (as may be seen by referring to the table at the end of the last article) each member differs from its neighbour by $C\ H_2$, thus forming a perfect arithmetical progression. Yet, from wood-spirit to the wax-alcohols, from marsh-gas to paraffin, from acetin to stearin, *no* colour occurs. Again, while aniline and its series are prolific in coloured derivatives, picoline and its followers, whose formulæ are exactly the same, prove to be sterile. Theoretical difficulties like these afford some partial glimpses of the enormous territory that chemistry has yet to conquer.

STAR-COLOURS.

BY THE REV. T. W. WEBB, M.A., F.R.A.S.

It can be matter of no surprise that the Great Creator should have thought fit to diversify the stars with such a variety of hue. On the contrary, it is fully consistent with the analogy of all his works. Everywhere we see beauty of colour not less provided for, than proportion of form: and the aspect of a flowery meadow in its exuberance of tints would naturally prepare us to expect something of a corresponding character in the expanded fields of heaven. And there we find it; if not with such extreme contrasts of hue, yet with diversities quite sufficient to do more than attract our notice, by gratifying in a high degree our sense of beauty.

But, though not surprising, the fact is a very interesting one, and connected with considerations more important than the mere pleasure of the eye. The identity of nature, which we may consider fairly established, between those remoter suns, and the central luminary of our own system, gives a special significance to every token of individual diversity; and that significance is accidentally of greater weight in the present case, because it has been hitherto scarcely possible to study those distant globes, excepting through the character of their light. Of their masses and densities we are likely to remain for ever as ignorant as we are of their real magnitude; a few only have given up the secret of their distance; and that in such a way as to afford us but little hope of ever extending our measuring line to the minuter millions that throng the expanse in all directions. The recent very remarkable discovery of their perceptible heat does indeed open out a most curious train of research, but one of very difficult prosecution, and probably limited extent; and the possible detection, in certain cases, of their planetary trains must always remain with the possessors of a few colossal instruments. It is not to be forgotten that anomalies—or what may seem such to us—may exist; that some inconspicuous and as yet neglected stars may show an unexpected amount of parallax; that some of the smaller ones may be found to emit a disproportionate degree of heat; or that attendants shining only by reflected light may be detected in positions where their presence would hardly be anticipated. Every possibility must be kept in view; especially in the present state of scientific progress, when all the more promising lines of research have already been followed out to such prolonged distances: and it is in the judicious choice and careful and unwearied prosecution of some of these more recon-

dite inquiries that the chief hope of distinction for an astronomical student now lies. But, though any of these approaches might be well chosen by those who have leisure and needful means, yet up to the present time no access to the nature of the stars lies so open as that through the constitution of their light. The quality which alone makes known to us their existence and position still offers the readiest advance in studying their nature; and of light, as colour and brightness are the two most striking characteristics, so each deserves to be separately examined. The variation of light has long attracted the notice of able observers: it is now quite time that the peculiarities of colour should receive a fuller share of attention. And for this the means will be readily found in the daily increasing ranks of amateurs who only wish for suitable employment. To quote the words of one of the greatest masters of the subject, Admiral Smyth, "In the discrimination of colours, zeal and ability can render good service to the general cause; yet without the observer's encountering heavy work, or toiling on monotonous reductions: . . . (the inquiry) may be advantageously encountered by any diligent sharp-sighted amateur, who, possessed of a good telescope, and inclined only to easy and pleasing work, is nevertheless zealous to become useful in the cause of knowledge."

But it may be said, and with much show of reason: Such researches may have had their relative value some years ago; but they have now fallen back into an unimportant rank. It is the spectroscope from which we are to claim further information as to the constitution of those distant suns. It has already worked wonders in the hands of Huggins and Secchi; and when the magnificent apparatus now in progress for the former is completed, what may not be expected from it? And though its more delicate indications must of course remain beyond the reach of ordinary amateurs, yet the smaller instruments which owe their perfection to the skill of Browning have quite power enough to show the more prominent features of the stellar spectra; and it is in this direction, rather than in that of mere eye-estimation, that the enterprise of observers should be directed.

This reasoning is, however, more specious than sound. It assumes that the spectroscope can do everything that can be done by the eye, and more: but the assumption is not correct. It can do what is more interesting and more valuable, as revealing much, otherwise wholly unsuspected, of the internal constitution of the source of light: yet there are points in which its indications require to be supplemented by ordinary vision. The eye is capable

of detecting many distinctions in colour which the prism is incompetent to deal with. Mere colour is, of course, no criterion of the composition of light; since the elementary bands may be entirely dissimilar in combinations of colour which produce the same effect upon the eye: and this is known to be the case among the stars. But, on the other hand, simple vision is fully competent to discriminate among shades of colour where the spectroscope would be altogether at fault: and even when the difference of hues amounts to contrast, the instrumental results fall far short of the unhesitating and peremptory judgment of the sight. This point has, perhaps, not been sufficiently attended to: yet the remark is capable of the easiest verification. The spectra of even oppositely-tinted substances will often be found much less unlike than would have been supposed; and in the detection of delicate gradations the whole balance will be in favour of the unaided eye—the feebleness of the deficient hues in prismatic dispersion being less apparent to the sense, than the strength of the prevailing ones in the united result. It would, therefore, be a superficial criticism that would depreciate the examination and registration of star-colour as a childish amusement in comparison with the labours of spectrum-analysis. It is, no doubt, far less laborious, and, at the same time less instructive; but it has its uses, and they are not without an importance of their own. It will be easy to point out two respects in which these eye-estimates possess considerable value.

The first is, the incompleteness of every attempt at a natural history of the heavens in which this characteristic finds no place. It is surely only correspondent with the existing "stand-point" of astronomy that each sufficiently conspicuous star should have its own appropriate description: and if magnitude and position only are specified, however adequate these may be for mere identification, the catalogue has no more pretension to completeness than a botanical work, in which all mention of the colour of flowers had been omitted. In this point of view, therefore, very much remains to be done.

A second reason is, that it is chiefly by eye-estimation that we shall accumulate evidence respecting that very curious phenomenon, a change of colour in certain stars: a phenomenon importing consequences which, however inappreciable at such an enormous distance, must in themselves be of very serious magnitude. There can be little doubt as to the fact; especially as it is related in connexion with the most conspicuous object in the whole starry heavens. No question can be entertained as to the intense whiteness of *Sirius* at the present day: or, if there is any slight tinge, it is rather of a

sapphire cast. Yet he was not only classed among the ruddy stars in the ancient catalogue of Ptolemy, but called red by Horace, and (though less unequivocally) by Cicero: and, what is even more to the purpose, is distinctly asserted by Seneca to be of a keener, or more vivid red, than Mars: so that Humboldt considers a change of colour to be historically proved. It seems also incontestable that the Great New Star of 1572 changed from white through yellow to ruddy during the degeneration of its lustre. The curious variable *R. Geminorum* has been described by its discoverer, Hind, as passing through shades of blue, yellow, and red, during its change of brightness; and among double-stars, where juxtaposition gives especial facility to comparison, suspicions of such alterations have been pretty freely entertained. However wonderful may be the results justly to be expected from the prismatic analysis of these phenomena, the first intelligence of them will probably be communicated by a simpler mode of observation. We have then abundant ground for asserting, without prejudice to spectrum-analysis, that the eye, especially when aided by telescopic power, may be profitably employed in independent researches into the character of stellar light: and we may express some surprise that this interesting study should remain so incomplete in the present state of astronomy; as well as the confident hope that, from the ease of its prosecution, it may soon be brought up to a point corresponding with our general advance in this glorious study of the works of the Creator.

It will not however be supposed that a charge of entire neglect is implied in what has been said. On the contrary, much has been done; but so done that it calls for more: it has been unequable and partial, and confined almost exclusively to double stars, when it ought to have been by this time extended to every object of sufficient magnitude in the heavens. The earliest observers, who were assuredly deficient neither in acuteness nor perseverance, could not fail to be struck with such contrasts as are exhibited by Wega and Antares, or Betelgeux and Rigel: and six stars are enumerated by Ptolemy as having a fiery reddish cast (*Sirius* being one of them). The invention of the telescope, not merely intensifying known colour, but disclosing a new and more extended range towards either end of the spectrum, would naturally awaken a fresh interest in the subject; but it does not appear that any systematic attention was paid to it before the revolution effected in sidereal astronomy by the labours of Herschel I. His ever-faithful records would, however, have possessed greater value in this respect, had not his estimates contained a greater preponderance of red than has met

with the concurrence of later observers. This has been referred to the composition of his specula, but was more probably due to "personal chromatic equation," or peculiarity of vision. Struve I. went far ahead in the registration of star-colours, when his magnificent Dorpat Catalogue was in the course of formation. But no man has done more, or rather in point of refined accuracy no man has done so much, as our own great observer, Admiral Smyth. The acuteness of his colour-vision, sharpened by long exercise and special attention, perfected his invaluable Bedford Catalogue in this respect; and an idea of the minute gradation of his scale may be formed from the following enumeration of tints:—White, silvery, flushed, yellow of various shades from straw to topaz, orange, emerald, apple and sea-green, blue from cerulean to smalt, lilac, amethyst, purple, plum-colour, violet, garnet, rose, fiery red, ruby. By organs less sensitive than his, many of these delicate distinctions would not be recognized; but still, enough of contrast will remain to strike any but a deficient sight. For it is unquestionable that annoying deficiencies are to be met with, and it is important that any one disposed to undertake this branch of study should be previously satisfied that his colour-vision is normal. The caution is more needful than some persons may suppose. Dr. Wilson, who paid especial attention to the subject, was brought to the conclusion—rather a startling and far from a pleasant one—that probably not less than one-fiftieth of our population is as colour-blind as Dalton himself, mistaking red and brown for green, and purple for blue: and that the proportion, if all kinds and degrees of this defect were included, would rise as high as 1 in 20. A comparison with other sights, and especially a trial by arranging disordered skeins of wool, or pieces of other coloured material, according to their tints and shades, would therefore be a desirable preliminary on the student's part, lest his results should be vitiated without his being aware of it.

It may possibly be due in great measure to such peculiarities, not, however, excluding differences of instruments and climates, peculiar states of atmosphere and health, and other trifling but operative causes, that we meet with less agreement than might have been expected, when we review the labours of the fore-named and other eminent observers, who need not now be specified in detail. An unsatisfactory feeling is thus imported into the inquiry, which we should gladly have dispensed with. Still, the truth must be told; and the difficulty had better be comprehended in its full extent. As an illustration of such discrepancies—perhaps a some-

what extreme, but a very instructive one—we may cite the following observations of the colours of the fine double star *a Piscium*:—Struve I., greenish white, blue, 1831·16 (mean of 8 years). Smyth, pale green, blue, 1838·87: greenish and pale blue, 1850·8. Sestini, both white, 1844·8. Bishop's Catalogue (Dawes?) pale green, blue, 1842·9? 1845·7? Dawes, very white, white, 1846·923. Fletcher, both yellow, 1851·7. Miller, green, blue, 1852·3. Powell, both greenish white, 1854·8. Mädler, white, bluish, 1856·164. Secchi, white, orange-yellow, 1855·793: both white, 1855·799: white, blue, 1857·0: adding, that the colours seem uncertain. Wrottesley, pale yellow, bluish, 1858·7. Dembowski, white, ashy white, 1854·44: pale bluish green, pale ashy green, 1856·12; 1858·12. Knott, pale or greenish yellow, ruddy or brownish yellow, 1862·9. Webb, faint yellowish green and ruddy, 1848·9; yellow, pale blue, 1850·0 (not a good night): not much difference with 80, with 144 at first glance B bluish, afterwards tawny, 1850·01: nearly the same with 80, with 144 and 250 pale yellow, brown yellow, a splendid night and very satisfactory observation, 1855·86: the foregoing all with a 3·7 inch aperture. With 5·5 inches, pale yellow, tawny or fawn-coloured, certain, 1860·96: no strong contrast, B perhaps on the whole bluish, but variable and undecided, 1862·89. It would obviously be but a precarious conclusion, to infer the fact of change from evidence so discordant; the more direct result is a lesson of self-distrust and caution, and of the necessity of a multitude of observers and observations in order to obtain a reliable mean, the deviations from which will probably become gradually more intelligible from careful attention and comparison.

We have already referred to the fact, that the vein of double-star colours has been very fairly worked, while solitary hues have been comparatively neglected. It is obvious, however, that much still remains unsatisfactory even in the former class, while the latter is as a whole very little explored: so that in either there is abundant room for labour; and we now propose to offer a few words as to the mode of directing it to advantage; while expressing our regret that we have so little carried out our own ideas on the subject, that we ought to be ashamed of obtruding advice upon others.

To note and to record, in leisure hours, the hue of each prominent star that is either looked for, or passes casually through our telescopic field, is certainly an easy and a pleasant undertaking. And this, in the hand of a sufficient number of observers to eliminate personal, instrumental, and atmospheric equation, is all that we have been pleading for. But some precautions are requisite to make its results

of value. We have already specified the normal state of the eye: we have yet to guard against the imperfections of the telescope. The achromatic, as is well known, does not correspond with its name. If we except the most ingenious, but scarcely practicable and now almost forgotten device of Blair, or the equally successful and too little known compensation recently introduced by Wray, such a thing as a colourless refractor does not exist. Every object-glass shows a fringe of uncorrected and incorrigible colour round the focal image of bright objects under high powers: the tint differs a little in the work of different makers, but is usually some shade of blue. The abstraction of this misdirected light from that concentrated in the image must of course give to the latter a slight tinge of the complementary colour, and the image of a white star will thus be flushed with a slight orange glow. In the case of the great Dorpat telescope, the noblest work of Frauenhofer, Struve I. remarks that the higher powers, 532 and 848, made a yellowish tinge visible. The reflector, though delightfully free from all coloured fringes, is not more perfect than the achromatic in the tint of the image, the blue rays thrown out by the object-glass on the one hand being absorbed by the silver film on the other; so that the result is much the same: and in each case a mental allowance may either be made for a little deterioration of whiteness at the time of observation, or it may be understood that the colours are recorded just as they appeared. It may often be found of service to put the object considerably out of focus either way, as the hue of a disc may be more sensible than that of a point; and we may thus in some cases escape errors due to the imperfect achromaticity of the object-glass, which will not be equally apparent on each side of the focus: of which I have had experimental certainty. It is safest to estimate the tint in the centre of the field, as the Ramsden ocular is never achromatic, and other eye-pieces, claiming that quality, do not always possess it. A state of atmosphere in which the sun would have a ruddy cast ought of course to be avoided, and colours cannot be depended upon in our climate, and under ordinary circumstances, within some distance of the horizon, as they are interfered with by the refractive action of the atmosphere. "In addition," Smyth tells us, "to the colouring and absorbing effect of the atmosphere increasing so excessively, low down on the horizon, the envelope acts so strongly there as a prism, that, combined with the bad definition prevailing, I have sometimes seen a large star, of a really white colour, appear like a blue and red handkerchief fluttering in the wind: the blue and red about as intense and decided as they

could well be." Struve I. found these prismatic colours visible in a dark field as far as 30°, and their traces even to 45° from the horizon; and every estimate below 15° worthless. The same authority has stated that the tints are not to be trusted on the blue background of a daylight sky. In fact, every deception arising from contrast ought to be guarded against; and this source of error operates in more than one way. A retina which has recently been exposed to artificial light, hardly ever of a pure white, will require to be kept in the dark for a little time in order to pass an unbiassed judgment: and the presence of a large and strongly-coloured star in the field will be sure to tinge its feebler neighbours with the complementary hue: and this may no doubt be to a certain extent the reason why so many minute companions to orange or yellow stars have been entered as blue; but it is certainly not the sole cause. "We all know," says Smyth, "that a white light appears greenish when near a strong red one, and becomes bluish when the neighbouring colour is yellow. In combinations of this nature some of the secondaries lose their colour on hiding the primary; but, as many of the examples defy this test, their colours are too decidedly indicated to be merely imaginary. For instance, as *α Leonis* is of a brilliant white tint, the deep purple of its *comes* cannot be an illusion; and in *δ Serpentis* both the bodies are blue." I do not know whether the peculiar tendency which I found in the use of my 3·7-in. object-glass, to see many of Smyth's small blue *comites* of a tawny hue—or sometimes changing from one to the other, may have been owing to their being enveloped in the outstanding deep blue fringe of the brighter star, and having their real tint thus over-ruled by contrast: but the circumstance recurred too frequently to be overlooked.

The following analysis of results, given by Struve I., is interesting in many respects. He found among 596 bright double-stars, 375 pairs of the same colour and intensity; 101 of the same colour, but different intensity; 120 of totally different colours. 295 were both white; 118 both yellowish or reddish; 63 both bluish: and the combination of a blue companion with a more vivid primary happens 53 times with a white principal; 52 with a light yellow; 52 with a yellow or red; 16 with a green. The curious fact is here made evident, that when the brighter star is not white, it approaches the less refrangible end of the spectrum, and the reverse: so that the very remarkable statement of Herschel II., that "no green or blue star (of any decided hue) has, we believe, ever been noticed unassociated with a companion brighter than itself," is shown to be, if

not literally, yet substantially correct. Smyth's "pale sapphire" for *Wega,* and "pale emerald" for β *Libræ* (in both of which tints my own sight corresponds, adding, with my present reflector, ϵ *Orionis* to the green list) have nothing like the intensity of colour which marks *Antares, Aldebaran,* and other great stars, towards the red end of the spectrum: it is reserved for the smaller stars in β *Cygni,* δ *Cephei,* γ *Andromedæ,* 32 *Eridani,* a *Herculis,* ρ^1 *Orionis,* and other similar objects, to show how decided a tint may be found towards the other extremity. This, though as yet uninterpreted, must be a significant fact. And so must be the circumstance that there is a peculiar class of ruby stars—the epithet "scarlet" or "blood-coloured" seems to the writer at least, rather over-pressed—the depth of whose hue has nothing corresponding with it at the other end of the spectrum. Very few of these stars unfortunately reach the limit of visibility to the naked eye: the so-called "Garnet sidus" of Herschel I., (μ *Cephei*) would be very improperly ranked with them, as its colour, though rich and full, is, at present at least, merely orange, without any of the peculiar carmine tinge which marks these curious objects as a distinct class; and the same may be said of the great fiery-looking *Antares.* Many of these beautiful rubies have been pointed out by Herschel II., and Schellerjup has given a catalogue (Astr. Nachr. 1591) of 280, in which, however, several occur which, according to Secchi (Monthly Notices, xxviii. 7), are merely yellow, and which does not include some genuine red objects discovered by Lassell, Knott, Birmingham, and others. It is, however, the best list extant; and has been reprinted in an abridged form in INTELLECTUAL OBSERVER, LVI. Many of these red stars have been prismatically examined by Secchi, with the singular result that their spectra differ very widely in character, and belong to various types. They are usually solitary; but Herschel II. observed a scarlet pair at the Cape; and has remarked that it is no uncommon thing to find a very red and much brighter star in a conspicuous situation in groups and clusters. Secchi has made a corresponding statement with regard to the structure of certain parts of the Galaxy. It is a singular and interesting fact that the central portion of the magnificent globular cluster 47 *Toucani,* unfortunately invisible in our latitudes, is of a ruddy colour, the margin being white. I do not know whether a suspicion that I have entertained, that some regions of the heavens are characterised by the predominance of some especial colour, may be borne out by further examination; but it may be at any rate worthy to be kept in view.

One of our most accurate observers has communicated to me his

impression, that some nights are more suitable than others for the minute discrimination of colour. It is certainly very probable. I am able to refer to an observation so far back as 1832, October 8, when notwithstanding an unfavourable white haze, the colours of Jupiter's satellites were "unusually contrasted:" and it is very possible that careful comparison may bring out the reality of this, as of other hitherto little noticed facts.

There seems no reason why any amateur should be discouraged by the smallness of his telescope, so long as he will content himself with such objects as have light enough for its grasp. In gradually increasing the size of my own working tools from 3·7 to 5·5 inches (achromatic) and at present to 9 inches (silvered glass), I cannot say that I have found a corresponding advantage in the perception of colour. Unfortunately for the present purpose, I have not now my former instruments for a comparison: but my impression is that I used to see contrasted tints, in the case of the brighter stars, even more strikingly with the smaller aperture. And this idea is in accordance with the opinions of Huggins and Slack and the experiments of Browning: the remark of the latter is worthy of great attention: "Were due allowance made for this disturbing influence of variation of aperture, I think many discrepancies between the colours attributed to double stars by different observers might probably be reconciled."

It seems accordant with analogy that, as a certain proportion of power to light is found to ensure the best vision of minute details, so a certain quantity of light may be more suitable than any greater or less amount for the fullest reception, on the part of the retina, of its characteristic colour. As, beneath a certain degree of brilliancy, colours, at least to ordinary eyes, become feeble and undecided, so above it they may probably be diminished by the glare and excitement of too great intensity. Many of the phenomena of vision are subjective, depending upon the capacity of the eye, and the conditions under which the optic nerve is most sensitive to the exciting influence; and it is very conceivable that the retina, disturbed by the vehement stimulus of a glaring light, may respond less faithfully to the gentler vibrations that produce the sense of colour. As yet little is known about this point; and it would be especially complicated with "personal equation"; but experiments with many different apertures deserve a trial, which, from want of leisure, and other circumstances, I am not likely to undertake; and which, in any case, ought not to depend on any single observer. I may mention, however, that on one occasion, in viewing γ *Andromedæ* with a

diagonal prism reflecting only from its anterior surface, and intended to adapt my 9-inch mirror for solar observation, I noticed that the colour of the large star was deepened from yellow to orange, the smaller being rather too dim for comparison, owing to the very great defalcation of light.

In order to assist observers in registering colours on an uniform scale, Admiral Smyth, in his "Sidereal Chromatics," printed in 1864 for private circulation, prepared a diagram containing 24 tinted discs, each representing in regular gradation some shade of six chosen colours, red, orange, yellow, green, blue, purple: with the intention that the observer should describe the colours of stars by matching them with these specimen-tints. Some difference of opinion may be permitted as to readiness of comparison between a glittering and flashing point, and a wafer-like circle of dead and opaque colour; but, in all probability, a little practice would render the observer independent of actual comparison. The essential advantage of the plan may be secured if we remember to designate the deepest conceivable star-tint by the numeral 1 attached to its name; a full and striking, but not singularly deep tint of the same colour, by 2; an ordinary shade by 3; and a pale tinge by 4. Thus γ *Andromedæ* in the Admiral's own notation is expressed thus, A orange$_2$ B bluish green^3 :—ϵ Boötis, A orange^3, B green^4: *a Herculis*, A yellow^2, B blue^3. He has designated in like manner "the very numerous shades from white to pale yellow," as creamy white 1, silvery white 2, pearl white 3, pale white 4: but these can hardly be required by the student. Practice will render such a mode of registration easy and pleasant, and though of course open to considerable uncertainty, it will be more satisfactory than any more vague and indeterminate kind of description. Other names of colours may be suitably introduced, such as rosy, copper-coloured, lilac (expressing a tint of common occurrence, between red and neutral purple), but the essentials of the system will be maintained by the adoption of numerals to express the intensity of the observed hue.

[Mr. Webb's remarks about refractors and reflectors, p. 487, seem to want slight correction, as the colours of Jupiter last year were not seen in many refractors, and in none so well as in Browning's admirable reflectors with the With mirrors. The yellow tints may have looked brighter from some absorption of blue, but the remarkable blue of Saturn, as shown in Mr. Browning's drawing, was beautifully shown by the same instrument.—Ed.]

THE OWL-PARROT, OR KAKAPO.

(*Strigops Habroptilus.*)

(*With a Coloured Plate.*)

BY T. W. WOOD, F.Z.S.

A SPECIMEN of this very interesting bird was deposited, a short time ago, in the collection of the Zoological Society of London. It is the first of its species that has ever reached England alive, although others have been forwarded with that intention: notably one by Sir George Grey, when Governor of New Zealand, which unfortunately died during the voyage. The individual now under notice has been removed by its owner to his own residence, and, although members of the Society may regret its absence from the menagerie, the ordinary visitors lose nothing by its removal, as the bird, persisting in his nocturnal habits, was always hidden in its box in a dark corner during the hours of daylight.

The point of greatest interest in this species is its having owl-like characteristics in combination with those of an ordinary parrot, and although the latter predominate, the former are quite apparent. The plumage is remarkable in this respect, having the rich green which predominates in the parrot family, combined with blackish brown mottlings and transverse bars, with dashes of pale yellowish buff peculiar to almost all owls. I could not help being struck by the circumstance which, no doubt is observable when the bird is in its native haunts, that these colours are absolutely the same as those which immediately surround the bird; the green colour being that of the grass, the yellow dashes the same as the oats and other grain on which the bird feeds, and the blackish brown bars imitating the soft mould, which, with grass, Mr. Misselbrook, the head keeper, with his usual good judgment, had caused to be placed for his charge to run upon; this he did with great glee, and most frequently and continuously in the attitude I have attempted to portray in the figure in the background of the coloured plate, the neck being so twisted that the position of the head is inverted, the point of the bill pointing upwards, and the top of the head being towards the ground. In this grotesque attitude, and evidently for the fun of the thing, the bird will run briskly round and round for five or ten minutes, to the great discomfiture of his portrait-painter, whose desire was to represent him in an attitude worthy of the dignity of so distinguished a member of his tribe. Several other species of parrot, and most of the cockatoos, are fond of twisting their

NEW ZEALAND OWL-PARROT.

St[illegible] habroptilus.

necks, apparently to the utmost extent of twistability of that organ, and the cockatoos, especially from the strong sense of humour which they constantly display, are not unworthy to be considered as the clowns amongst birds. This humorous disposition does not seem to be discoverable in any of "our feathered friends" but those of the parrot tribe, and perhaps this fact will be admitted as proof that these birds are more intelligent than those of any other family.

"With regard to the particular bird in my possession," says Mr. G. S. Sale, "I observe that it rarely makes any noise by day. But about dusk it usually begins to screech, its object being apparently to attract attention, for, if let loose from its cage and allowed to have its usual play, it ceases to make any noise. It also makes a grunting noise when eating, especially if pleased, and I have myself attracted it to me by imitating the same sound. It also screeches sometimes when handled, not apparently from anger, but more from timidity." In a note Mr. Sale adds: "The sound of the bird is not a shrill scream, but a muffled screech, more like a mingled grunt and screech."

As Mr. Sale had this bird in his possession for several months before depositing it at the Zoological Gardens, and during that time carefully watched its habits, the following additional remarks of his in a letter to "The Field" newspaper will be worth quoting: "Sir G. Grey exactly hit the chief characteristics of the kakapo, when he spoke of its affectionate and playful disposition. During the whole time that this bird has been in my possession, it has never shown the slightest sign of ill-temper, but has invariably been good-humoured and eager to receive any attention. Its playfulness is remarkable. It will run from a corner of the room, seize my hand with claws and beak, and tumble over and over with it exactly like a kitten, and then rush back to be invited to a fresh attack. Its play becomes sometimes a little severe; but the slightest check makes it more gentle. It has also, apparently, a strong sense of humour. I have sometimes amused myself by placing a dog or cat close to its cage, and it has danced backwards and forwards with out-stretched wings, evidently with the intention of shamming anger, and has testified its glee at the success of the manœuvre by the most absurd and grotesque attitudes. One trick especially it has, which it almost invariably uses when pleased, and that is to march about with its head twisted round, and its beak in the air—wishing, I suppose, to see how things look wrong way up, or perhaps it wishes to fancy itself in New Zealand again.

"The highest compliment it can pay you is to nestle down on your hand, ruffle out its feathers, and lower its wings, flapping them alternately, and shaking its head from side to side; when it does this it is in a superlative state of enjoyment. I do not think it is quite correct to say that it has dirty habits; certainly it is not worse in this respect than an ordinary parrot.

"I am surprised to find that during the time it was in the Zoological Gardens, it very rarely showed itself in the daytime. My experience has been the reverse of this. It has generally been lively enough during the greater part of the day, though not quite so violent and noisy as at night. I had this bird at Saltburn, in Yorkshire, during the summer, and any of your readers who were at that place in the month of August, will remember seeing this bird at the bazaar held in aid of the district church, on which occasion its playfulness never flagged during the whole day. This may partly have been due to excitement at seeing so many strange faces; but it also no doubt felt the excellence of the cause (recollect, Sir G. Grey testifies to its cleverness and intelligence), and exerted itself accordingly to help the Church Building Fund." Mr. Sale remarks in conclusion, that the bird was forwarded to him by his friend, Mr. Abbot, Registrar of the Supreme Court at Hokitika, and was purchased by him from the West Coast natives.

The Kakapo appears to have been first known to European explorers by its green feathers, which were worn by the natives of New Zealand, who formerly set great store by these birds, cutting off their heads, which were strung by the nostrils, and worn in the ears on feast days. The bird itself long remained unknown to Europeans; its practice of hiding by day in holes in the ground, and its wonderfully disguised plumage, will sufficiently account for this, and it was not till the year 1845 that the first skin reached Europe. It is said to be exclusively a vegetable feeder, and to have a voracious appetite; and those who have tasted its flesh say that it is tender and of exquisite flavour, the large quantities of fat under the skin being firm and white. The Kakapo is often kept in captivity in its native land.

This remarkable bird certainly possesses the facial disc so characteristic of the owl tribe, although not in so marked a degree. The feathers of the face are somewhat different in colour and appearance from those on other parts of the body, being rather elongated and hairy, especially those close to the beak, their colour being a light yellowish-brown, which becomes darker on the ear-coverts. There is a pale yellowish stripe over each eye, and this joins an indistinct

band of the same colour which edges the disc. The eyes do not appear to be larger in proportion than in other parrots, and this is contrary to what might have been expected, considering the other owl-like characteristics. These organs appear to be black in colour, but it is probable that, as usual in such cases, the irides are of a very dark brown.

I will here venture to express my opinion that naturalists are too apt to overlook some of the external features of the objects of their study, such as the markings and texture of the feathers of the birds, or the general colouring. To take these characters alone in the Owl-parrot, they will be found to indicate its position in the great scheme of nature as being intermediate between the owl and parrot tribes. Taking all the characters together, however, they will be found to express a decided leaning towards the parrots. I cannot, therefore, but consider this bird as a true link uniting the owls to the parrots, although it is not an exactly intermediate one. One objection which may be urged against this opinion I will endeavour to combat—namely, that the parrots have zygodactyle toes, whereas the owls have not. To this I would answer that the foot of an owl, when the bird is perched, considerably resembles that of a parrot, as the outer toe is then placed behind with the hind one, so that this bird's feet may be said to be temporarily zygodactyle, whereas those of the parrot are permanently so.

Sir George Grey has given the following interesting account of this bird, as observed by him in its native country:—

"The Strigops is called Kakapo, or Night Kaka, by the aborigines of New Zealand, from the nocturnal habits of the bird. During the day it remains hid in holes under the roots of trees or rocks, or very rarely perched on the boughs of trees with a very dense thick foliage. At these times it appears stupid from its profound sleep, and if disturbed or taken from its hole, immediately runs and tries to hide itself again, delighting, if practicable, to cover itself in a heap of soft dry grass; about sunset it becomes lively, animated, and playful, issues forth from its retreat, and feeds on grass, weeds, vegetables, fruits, seeds, and roots. When eating grass it grazes rather than feeds, nibbling the grass in the manner of a rabbit or wombat. It sometimes climbs trees, but generally remains upon the ground, and only uses its short wings for the purpose of aiding its progress when running, balancing itself when on a tree, or in making a short descent, half jump, half flight from an upper to a lower bough. When feeding, if pleased with its food, it makes a continued grunting noise; it is a greedy bird and choice in its food, showing

an evident relish for anything of which it is fond. It cries repeatedly during the night, with a noise not very unlike that of the kaka (the nestor), but not so loud.

"The Kakapo is a very clever and intelligent bird, in fact, singularly so; contracts a strong affection for those who are kind to it. Shows its attachment by climbing about and rubbing itself against its friend, and is eminently a social and playful bird; indeed, were it not for its dirty habits, it makes a far better pet than any other bird with which I am acquainted, for its manner of showing its attachment by playfulness and fondling is more like that of a dog than a bird.

"It builds in holes under trees and rocks, and lays two or three white eggs about the size of a pullet's, in the month of February, and the young birds are found in March.

"At present (1854) the bird is known to exist only in the Middle Island of New Zealand, and the west coast between Chalky Harbour and Jackson's Bay, and in the Northern Island about the sources of the Whangarie, and in part of the Taufa countries.

"It was within the recollection of the old people abundant in every part of New Zealand, and they say it has been exterminated by the cats introduced by the Europeans, which are now found wild and in great numbers in every part of the country. They say also that the large rat introduced from Europe has done its part in the work of destruction.

"The natives assert that when the breeding season is over the Kakapo lives in societies of five or six in the same hole, and they say it is a provident bird, and lays up in the fine season a store of fern root for the bad weather. I have had five or six of the birds in captivity, but never succeeded in keeping them alive for more than eighteen months or two years. The last I had I sent home as a present to the Zoological Society, but it died off Cape Horn."

I will also quote the following valuable particulars of the Kakapo in its wild state, which were communicated to the Zoological Society by Mr. David Lyall, who wrote as follows:—

"Although the Kakapo is said to be still found occasionally on some parts of the high mountains in the interior of the North Island of New Zealand, the only place where we met with it, during our circumnavigation and exploration of the coast of the islands in H.M.S. 'Acheron,' was at the south-west end of the island. There, in the deep sounds which intersect that part of the island, it is still found in considerable numbers, inhabiting the dry spurs of hills or

flats near the banks of rivers, where the trees are high, and the forest comparatively free from fern or underwood.

"The first place where it was obtained was on a hill nearly four thousand feet above the level of the sea. It was also found living in communities on flats near the mouths of rivers close to the sea. In these places its tracks were to be seen resembling footpaths made by man, and leading us at first to imagine that there must be natives in the neighbourhood. The tracks are about a foot wide, regularly pressed down to the edges, which are two or three inches deep amongst the moss, and cross each other usually at right-angles.

"The Kakapo lives in holes under the roots of trees, and is also occasionally found under shelving rocks. The roots of many New Zealand trees growing partly above ground, holes are common under them; but where the Kakapo is found many of the holes appeared to have been enlarged, although no earth was ever found thrown out near them. There were frequently two openings to these holes, and occasionally, though rarely, the trees over them were hollow for some distance up.

"The only occasion on which the Kakapo was seen to fly was, when it got up one of these hollow trees and was driven to an exit higher up. The flight was very short, the wing scarcely being moved; and the bird alighted on a tree at a lower level than the place from whence it had come, but soon got higher up by climbing, using its tail to assist it.

"Except when driven from its holes, the Kakapo is never seen during the day, and it was only by the assistance of dogs that we were enabled to find it.

"Before dogs became common, and when the bird was plentiful in inhabited parts of the island, the natives were in the habit of catching it at night, using torches to confuse it. It offers a formidable resistance to a dog, and sometimes inflicts severe wounds with its powerful claws and beak. At a very recent period it was common all over the west coast of the Middle Island, but there is now a race of wild dogs said to have overrun all the northern part of this shore, and to have almost extirpated the Kakapos wherever they have reached. Their range is said to be at present confined by a river or some such physical obstruction, and it is to be feared that if they once succeed in gaining the stronghold of the Kakapo (the south-west end of the island) the bird may soon become extinct.

"During the latter half of February and the first half of March, whilst we were amongst the haunts of these birds, we found young ones in many of the holes, frequently only one, never more than two

in the same hole. In one case where there were two young ones, I found also an addled egg. There was usually, but not always, an old bird in the same hole with the young ones.

"They build no nest, but simply scrape a slight hollow amongst the dry dust formed of decayed wood. The young were of different ages, some being nearly fully fledged, and others covered only with down. The egg is white, and about the size of a pigeon's.

"The cry of the Kakapo is a hoarse croak, varied occasionally by a discordant shriek when irritated or hungry. The Maories say that during winter they assemble together in large numbers in caves, and at the times of meeting, and, again before dispersing to their summer haunts, that the noise they make is perfectly deafening.

"A good many young ones were brought on board the ship alive. Most of them died a few days afterwards, probably from want of sufficient care; some died after being kept a month or two, and the legs of others became deformed after they had been a few weeks in captivity. The cause of deformity was supposed to be the want of proper food and too close confinement. They were fed chiefly on soaked bread, oatmeal and water, and boiled potatoes. When let loose in a garden they would eat lettuces, cabbages, and grass, and would taste almost every green leaf that they came across. One, which I brought within six hundred miles of England (when it was accidentally killed), whilst at Sydney, ate eagerly of the leaves of a Banksia and several species of Eucalyptus, as well as grass, appearing to prefer them all to its usual diet of bread and water. It was also very fond of nuts and almonds, and during the latter part of the homeward voyage lived almost entirely on Brazilian ground-nuts.

"On several occasions the bird took sullen fits, during which it would eat nothing for two or three days at a time, screaming and defending itself with its beak when any one attempted to touch it. It was at all times of an uncertain temper, sometimes biting severely when such a thing was least expected. It appeared to be always in the best humour when first taken out of its box in the morning, hooking on eagerly with its upper mandible to the finger held down to lift it out. As soon as it was placed on the deck it would attack the first object which attracted its attention—sometimes the leg of my trousers, sometimes a slipper or a boot. Of the latter it was particularly fond; it would nestle down upon it, flapping its wings, and showing every symptom of pleasure. It would then get up, rub against it with its sides, and roll upon it on its back, striking out with its feet whilst in this position.

"One of these birds sent on shore by Captain Stokes to the care of Major Murray of the 65th Regiment at Wellington, was allowed to run about his garden, where it was fond of the society of the children, following them like a dog wherever they went.

"Nearly all the adult Kakapos which I skinned were exceedingly fat, having a thick layer of oily fat or blubber on the breast, which it was very difficult to separate from the skin. Their stomachs contained a pale green, sometimes almost white, homogeneous mass without any trace of fibre in it.

"There can be little doubt but that their food consists partly of roots (their beaks are usually more or less covered with indurated mud), and partly of the leaves and tender shoots of various plants. At one place where the birds were numerous we observed that the young shoots of a leguminous shrub growing by the banks of a river were all nipped off, and this was said by our pilot, who had frequented these places for many years in a whaling-vessel, to be the work of the Kakapo."

In size the Owl-parrot is rather smaller than a raven, the total length being 2 ft. 4 in.; the tail measures 9 in. The statement that this bird is a vegetarian has been confirmed by an experiment made by Mr. A. D. Bartlett, the superintendent of the Zoological Gardens, who has informed me that the Kakapo would not eat the meat which he offered, and that it would not catch a mouse.

ON POISONS.

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PART V.

IN the previous articles on poisons, the methods of detecting each of them has been treated of at length, and the most important chemical reactions by which they make their presence known have been given. The toxicologist, however, rarely meets with poisons uncombined with other substances, and his investigations are often greatly complicated by the presence of substances with which the poison he is searching for is accidentally mixed. The contents of the stomach of a person who has died from the effects of poison, are frequently submitted to him for examination, or he may have to search

in other organs of the body, such as the liver, or in the secretions, or excretions, for the poison which is supposed to have caused death. In these cases the presence of organic matter renders its detection much more difficult than when it occurs alone, or simply dissolved in water; for organic matter, as has been shown, unites with certain metallic salts, forming compounds, which must be decomposed before the metal can be recognized. Mercury and lead salts, it will be remembered, have a peculiar property of forming albuminates, and these albu inates must be destroyed before lead or mercury can be detected; that is, supposing that not more than enough of these salts to combine with the albumen, be present. When a person vomits, what is brought from the stomach is usually thick and viscid, containing generally partially digested food. Now, if a poison, say for example arsenic, be mixed with this, it would be impossible to employ any reagent for its precipitation, for if thrown down in the solid form, as it would be if thrown down at all, it would be so mixed up with the other substances present, that it would be impossible to separate it from them. Viscid organic matters frequently prevent precipitation, and albuminates are not decomposed by sulphuretted hydrogen, the reagent usually employed for separating metals, as sulphides, from their soluble salts. If the blood of a poisoned animal contain some of the poison, it must be in the form of some compound of a constituent of the blood, or so intimately mixed with it that the ordinary chemical tests fail to detect it. From what has been said, it will be manifest that some process must be adopted for the breaking up of metallo-organic compounds, and for the destruction, wholly or in part, of the organic matter, before the metals can be got to behave in their usual manner towards chemical reagents. Several processes are adopted for this purpose; burning or incineration is recommended by many as the best method, but it must be remembered that some of the metallic poisons and their salts are volatile at high temperatures, and therefore would by this operation be lost. Suppose an organic compound containing arsenious acid were heated to a temperature sufficiently high to destroy in great part the organic matter, where should we expect to find the arsenic? certainly not in the charred residue, for it has been shown that, when arsenious acid is heated with carbon —and all organic matter contains carbon—the acid is reduced to the metal, and that the metal escapes in the form of vapour, and even if it be not all reduced, that which remains as arsenious acid would be volatilized. If this experiment were performed in a closed vessel the arsenic might be sublimed and collected, but

generally the bulk of matter with which the toxicologist has to deal is so large in proportion to the quantity of arsenious acid present, that the operation would be exceedingly difficult, and the results attained highly unsatisfactory. Although the process of incineration is sometimes useful, it is by no means of universal application. Several methods are adopted for the destruction of organic matter in the detection of poisons, but that which appears to be the best, is, if the symptoms of poisoning lead to the supposition that the poison taken is metallic, to treat the matters to be examined with a solution of sodic hydrate (caustic soda), and warm them gently for some time, the liquid being distinctly alkaline, the mass will turn brown, and the organic compounds will be so far decomposed, after the liquid has been evaporated nearly to dryness, that on dissolving up with water, and acidulating with hydric chloride (hydro chloric acid), a clear and almost colourless liquid will pass through a filter paper, and this liquid will contain perhaps all, or the greater part, of the poison in solution, if it be arsenic, antimony, lead, or zinc. The solid matter remaining on the filter paper should be retained for further treatment if necessary. In this operation those metals which are volatile at high temperatures cannot escape. Oxides of arsenic, antimony, lead, and zinc enter into combination with the sodic hydrate, by expelling its hydrogen which unites with their oxygen forming water in the case of zinc the action is thus represented:—

$$\underset{\text{zinc oxide}}{ZnO} + \underset{\text{sodic hydrate}}{2\,(NaHO)} = \underset{\text{sodic zincate}}{Na_2ZnO_2} + \underset{\text{water}}{H_2O}$$

and it is typical of the rest; but silver, mercury, and copper are precipitated, and left behind as oxides. On treating with hydric chloride, after evaporation, the copper oxide is dissolved, but the others are left behind and do not pass the filter, except the mercury, which will be dissolved if it was originally present as a mercuric salt. If sulphuretted hydrogen be passed into the clear filtrate, sulphides of the metals present will be formed, which can be filtered and washed and submitted to methods of examination described in previous articles. The substance which remains on the filter paper should be placed in a Berlin dish and warmed with hydric nitrate (nitric acid), and evaporated nearly to dryness; on dissolving up the soluble parts of the residue in water the liquid may be analysed by processes which have been already explained.

It must be remembered, however, that if silver be present it will now be in the form of chloride, and cannot therefore be dissolved

by hydric nitrate. Should no copper or mercurous salt be detected, the residue should be treated with ammonia, which will dissolve the silver chloride, and it can be precipitated from this ammonic solution, after filtration with hydric nitrate, and be further examined, by converting it first into oxide by boiling it with caustic soda, and then dissolving up the oxide in hydric nitrate, which will give a solution of argentic nitrate, the most convenient form for applying confirmatory tests.

Sometimes, however, if the quantity of the metallic poison be small in comparison to the quantity of organic matter present, this method should only be tried on a small portion of it, and if no poison be discovered, then recourse must be had to a more complete and perfect method for the destruction of the organic matter. The process by which organic matters are best destroyed is by oxidation; and the most convenient substances to use for this purpose are potassic chlorate and hydric nitrate. The organic substances to be oxidized should first be evaporated to perfect dryness on a water bath—a higher temperature should not be employed for obvious reasons; the dry matter left should be then treated with hydric nitrate—the dish in which the operation is performed still being retained at a water bath heat; the hydric nitrate should be added freely, and when it begins to boil potassic chlorate should be thrown in in small quantities at a time. On each addition of the chlorate the liquid will froth rather violently, but the colour will gradually disappear, no more potassic chlorate being used than is necessary to produce this effect. After the whole of the colour has been discharged, the mass should be evaporated to dryness; it should then be dissolved in water, and boiled with sulphurous acid, which will reduce the chlorate which remains undecomposed, and which will also reduce the arsenic acid which has been formed by oxidation of arsenious acid with the chlorate. The boiling should be continued till all smell of sulphurous acid has disappeared, otherwise if any remained present, it would decompose the sulphuretted hydrogen, and cause a deposition of sulphur, the presence of which would be perplexing in examining the precipitated sulphides. The arsenic acid should be reduced, for if it is not, no precipitate would occur with sulphuretted hydrogen till after some time. But, inasmuch as the reduction of the arsenic acid may not have been complete, it is always well to keep the liquid which passes the filter, after the treatment with sulphuretted hydrogen, to boil it and allow it to stand for some hours; and collect any precipitate which may be found in it, as it may contain some of the arsenic. The substance, after treat-

ment with sulphurous acid, should be warmed with hydric chloride before passing into it sulphuretted hydrogen; and thus soluble salts of all the metals likely to be present, will be obtained, except silver and lead, which will remain undissolved as chlorides; how to treat the silver chlorides has already been explained. To discover lead it is best to boil with plenty of water, filter, and allow the liquid to cool; the lead chloride, which is not nearly so soluble in cold water as in hot, will be precipitated in crystals, and can then be examined by methods already described, as well as the solution, which will contain some dissolved lead chloride.

If copper be present in the substance to be tested, the liquid, after oxidation of the organic matter, will have a greenish hue more or less intense, according to the quantity of copper present; and this green colour will point out the direction which further examination should take. If zinc be the metal in the organic mixture, no precipitate of zinc sulphide will be thrown down in an acid solution; therefore, if hydric chloride has been added, it should be neutralized by ammonia, and rendered acid with acetic acid; and in such a solution white zinc sulphide is precipitated by sulphuretted hydrogen.

Our space will not allow of a more detailed description of processes employed in the detection of poisons; enough, however, has been said to show the general method employed, and to point out to those interested in the subject, certain processes which have not, I believe, as yet been made public. Before proceeding to consider a few of the most important organic poisons, it will be well briefly to allude to two classes of mineral substances which are well known, and which have been used as poisons. The strong mineral acids, commonly called oil of vitriol, muriatic acid, and aquafortis, when taken internally, act as irritant and corrosive poisons; they destroy the tissues rapidly, and if taken in large doses cause death in a few hours. Sometimes, however, the patient lingers for some weeks, and even if he recover, suffers for years, perhaps all his life, from deranged digestion. Such results must manifestly happen from the nature of their action, which is to disintegrate those membranes and glands which are essential to the work of digestion. The general symptoms produced by all these acids are very much alike; they produce great pain immediately we swallow them—as they burn the hand or any external part, so they burn the throat, gullet, and stomach, and the pain produced is more intense, because the injured surface is more sensitive. The countenance, from the great pain, expresses anxiety, the pulse is small and quick, the breathing laborious, the lips shrivelled and burnt, the inside of the mouth is

white, and generally exhibits external marks, produced by the acid, are visible on the face, especially about the chin and neck.

The best treatment is to give magnesia, chalk, or whiting, to neutralize the acid; milk is recommended as a vehicle for their administration, though they are generally suspended in water. Mucilaginous drinks may be given freely as well as oil, so these latter may be continued for some time. It is dangerous to use the stomach pump, as the parts are by the acids so much softened and destroyed. Leeches are sometimes applied to subdue inflammation, and bleeding may be found necessary.

After death, it is found that great destruction has been caused by the acid to the alimentary canal, the stomach is often perforated, and the membrane which lines the abdominal cavity is often found to be highly inflamed, even if no perforation of the stomach has been caused. The differences between the three acids are in some respects very marked, though their actions on the body are similar. Oil of vitriol is a heavy oily liquid, generally brown from the effects of organic matter, but when pure it is colourless. It is used for cleaning copper vessels, and for other domestic purposes; in the dilute state it is used as a medicine, and has astringent properties. It is given in hæmorrhages, and as a tonic in extreme debility. It is also supposed to be efficacious in stopping diarrhœa. When vegetable substances are put into it, it chars them. If poured into a strong syrup it first turns it brown and then black; the action is violent and attended with great evolution of heat. Oil of vitriol, like other acids, reddens blue litmus paper, and changes the colour of black cloth to red. If the acid be strong when dropped on cloth or linen it does not dry, as one of its properties is to absorb moisture. The red colour which it causes when it acts on black cloth is destroyed by ammonia, and the black colour is restored. These points are of importance in medico-legal inquiries, as furnishing evidence of the nature of the poison which has been taken.

Oil of vitriol (hydric sulphate) is detected by the white precipitate which it gives with a soluble salt of barium, and which is insoluble in all acid liquids. When this precipitate is heated with charcoal and dried carbonate of soda, it is reduced, and a sulphide is formed which evolves sulphuretted hydrogen on the addition of an acid liquid, the sulphuretted hydrogen being detected by its smell or by its blackening paper moistened with plumbic acetate. When mixed with organic substances, they should be diluted with water and filtered; to the filtrate, chloride or nitrate of barium should be added, and a white precipitate will be formed if oil of vitriol or any other

sulphate be present. Hydric sulphate may be separated from hydric chloride, and hydric nitrate by distilling from a dilute solution at the temperature of a chloride of calcium bath; the two latter acids are volatile at such a temperature, and pass over, leaving the hydric sulphate behind. Sulphates may be present which have been administered as antidotes, such as sulphate of zinc, or if lime has been given, sulphate of lime will be found. And here it is necessary to consider the symptoms and post mortem appearances, for in cases of poisoning by oil of vitriol they are very distinct, and lead, if oil of vitriol in any quantity be found on analysis, to the conclusion that it was the cause of death.

Aquafortis, or hydric nitrate, is not often taken or administered as a poison. The symptoms which it produces are like those resulting from taking oil of vitriol, as also are the post mortem appearances; it is not, however, so corrosive in its action, and therefore perforations of the alimentary canal are not so common. The tests for its detection of course differ from those for hydric sulphate. In the first place, it causes *yellow* stains on black cloth, and the colour of these is not discharged by ammonia; and in the next, as all nitrates are soluble, it cannot be detected by precipitation.

Nitrates, when heated with strong hydric sulphates and copper, are decomposed and give off red fumes of nitrous acid; these can be detected by their colour and smell, but if present only in small quantities, by their action on paper moistened with iodide of potassium and starch. This they turn blue, for they decompose the iodide, setting iodine free, and free iodine causes, with the starch, the blue colour which appears. If, to some of the nitrates in solution, an equal bulk of strong hydric sulphate be added, and the mixture be allowed to cool, a solution of protosulphate of iron poured carefully on to the mixture will not mingle with it, but will float on its surface, and at the junction of the two liquids a brown ring will appear. In organic mixtures, the liquid should be neutralized with carbonate of potash and filtered, and the filtrate should be evaporated, and the nitrate will crystallize out. If the crystals be heated with carbon they will deflagrate. As magnesia and chalk are often given in cases of poisoning by the acids, it is well to neutralize with carbonate of potash, as magnesia and chalk are thus precipitated as carbonates, they being insoluble in water; but the nitrates are soluble, and nitrate of potassium will remain in solution, and to this, after crystallization, the tests for a nitrate may be applied. Some toxicologists recommend what is called the morphia test; it is performed in this way: a small piece of the

substance supposed to be a nitrate, should be placed on a white porcelain surface; it should be decomposed by strong hydric sulphate, and then a little morphia should be dropped in the liquid; if it be a nitrate, the morphia will become reddish yellow.

Muriatic acid or hydric chloride, commonly called spirit of salt, has in a few cases been used as a poison. The effects it produces are similar to those already described for the other acids. Like oil of vitriol, it makes red spots on black cloth, and the colour of the cloth is restored by ammonia. Soluble chlorides give a white precipitate with nitrate of silver, soluble in ammonia, insoluble in hydric nitrate. When heated with hydric sulphate and manganic oxide, chlorine is evolved.

In organic solutions it is best to distil off the acid, not letting the temperature rise above that of a bath of chloride of calcium. If a quantity of free hydric chloride comes off, and if the symptoms agree with poisoning by that substance, it may be safely concluded that it has been the cause of death. If the organic liquid is not strongly acid, owing to the administration, before death, of substances which have neutralized the acid, then it is well to add hydric sulphate before distilling, as it sets free hydric chloride; but here a preliminary test should be made to show that a sulphate is not present, at least in any quantity. When a sulphate has been administered, it is better to precipitate from the liquid filtered from the solid matter, the chlorides, with nitrate of silver, then to filter off the precipitated chloride of silver, wash it, and dissolve in ammonia. After filtering the ammonia solution, the silver chloride can be re-precipitated from it with hydric nitrate, and the silver salt on boiling with caustic soda is decomposed, oxide of silver being thrown down, while chloride of sodium remains in solution, and to this the confirmatory tests of a chloride can be applied.

The caustic alkalies and their carbonates, when taken in the concentrated form, act as instant and corrosive poisons. When swallowed, they produce a burning pain in the throat, violent pain in the stomach, colic pains and purging. The abdomen becomes tense and tender on pressure. Death generally takes place after a few hours, the patient dying in a state of collapse. From the caustic nature of the poison, the passage from the mouth to the stomach becomes constricted, and the person after a time dies of starvation. Acid drinks are given as antidotes; vinegar, lemon juice, and soothing liquors, such as oil, may be freely administered. If inflammation set in, it must be specially treated. As in poisoning by acids, and for the same reasons, the stomach-pump should not be

used. After death the marks of a corrosive poison are distinctly visible in the mucous membrane of the mouth, which is in part destroyed and softened; there is ulceration and extravasation of blood. The alkalies have not been known to produce perforation. Caustic potash occurs in various forms, in lumps, flat masses, and in circular sticks about the diameter of an ordinary pencil; it is very soluble in water, and also readily takes up moisture, becoming damp; it is a deliquescent substance. It is also kept in liquid under the name of liquor potassæ, and is used in medicine. It is detected by giving a yellow precipitate with the tetra chloride of platinum, it having been first converted into the chloride of potassium. In this respect it resembles ammonia. In testing for potash, the organic liquid supposed to contain it should be filtered and the liquid evaporated and heated to destroy organic matter, then hydric chloride should be added and heat applied, even after all moisture has been expelled, in order to drive off any ammonia salts which may be present; the residue should be dissolved and tetra chloride of platinum added; the occurrence of a yellow precipitate will indicate the presence of potash. If the potash has been given in the form of carbonate, on the addition of hydric chloride effervescence will take place, and carbonic acid gas will be evolved. Potash salts also give a crystalline precipitate with bitartrate of soda, for the bitartrate of potash is very slightly soluble in water, whereas the bitartrate of soda dissolves readily. Soda salts are not so easily detected as those of potash; the only reagent which gives an insoluble precipitate with them is the metantimoniate of potash. Soda may be obtained from organic solutions in just the same way as potash, and the substance being freed by heat from ammonia salts, may be treated with a solution of metantimoniate of potash, when a peculiar crystalline precipitate will be found, which generally adheres to the sides of the test tube. Ammonia is very rarely used as a poison. It occurs as liquid ammonia, and as sesqui-carbonate of ammonia; it is easily detected by its smell. Ammonia gas has sometimes caused death by producing suffocation. When a salt of ammonia is heated with caustic soda or potash, ammonia is set free, and can be recognized by its powerful odour. Ammonia gas, when it comes in contact with the fumes of hydric chloride, renders them very white and dense, and this is sometimes used for its detection. When ammonia has to be sought for in organic liquids, they should be first mixed with caustic soda and distilled, the ammonia will come over in the form of gas, and can be condensed in water, in which the gas is very soluble. Our remaining space will be devoted

to the consideration of one or two of the most common organic poisons.

Oxalic acid is a well known poison; it is cheap, and very active when taken in sufficient quantity, and is used extensively in manufactures. It is a poison rather used by the suicide than the murderer, owing to its strongly acid taste, for sufficient to cause death could hardly be administered without the victim perceiving it. It has sometimes been the cause of accidental poisoning, from its resemblance, in appearance, to sulphate of magnesia (Epsom salts), though its taste is very different—Epsom salts having a bitter and peculiar flavour. In 1837-38 nineteen cases of poisoning by oxalic acid occurred; of these, fourteen were cases of suicide. Oxalic acid is found in common sorrel (*oxalis acetosella*), not however as the acid, but as the acid oxalate of potassium. Other plants contain it, the barilla plant, in which it exists as oxalate of sodium; it is also found in common rhubarb. It is prepared on a large scale by heating sawdust with caustic potash; the potash is usually mixed with soda, as the mixture of the two is found to be more profitable. The alkali soda does not furnish the acid, and potash, if used by itself, would be too expensive. After the action is completed, the soluble salts are dissolved out from the mass, and the oxalate of sodium which is not so soluble, is left. The alkalies, after proper treatment are again prepared for further use, but the oxalate of sodium is boiled with lime, and the insoluble oxalate of calcium is formed; this is treated with oil of vitriol, which decomposes it, forming sulphate of lime and oxalic acid, which is crystallized out from the solution. The usual method of preparing oxalic acid is by the oxidation of sugar or starch, by hydric nitrate. The two are heated together in a retort; carbonic acid and nitrous fumes are given off. After the action has continued sufficiently long, the liquid is evaporated, and the oxalate crytallizes out. From the fact that oxalic acid was made from sugar, it received the name "acid of sugar." Oxalic acid, when pure, is entirely dissipated by heat, it breaks up into carbonic acid, carbonic oxide, and water. When heated with hydric sulphate it is decomposed into the same compounds, the carbonic acid and carbonic oxide escaping, while the water remains behind with the hydric sulphate. Oxalic acid is largely used by calico printers, and is very effectual in discharging the colour of ink stains from wood or linen. About half an ounce of the acid is a poisonous dose. When taken in this quantity it produces vomiting, causing a burning sensation in the throat; the vomiting, however, does not always occur, the patient

experiences great pain over the region of the stomach, and generally dies in a state of collapse. There are other symptoms more or less regular in their occurrence—such as perspirations, quick breathing, great prostration, from which it is difficult to arouse the patient, extreme pain in the abdomen, and numbness in the limbs immediately preceding death. The matters vomited are usually green or black, and contain altered blood. After death the mouth and throat, which have been affected by the acid, are white, the mucous membrane which lines them is disintegrated, it is soft and easily removed. The blood-vessels are filled with dark blood. The stomach is sometimes inflamed, at others pale like the mouth and throat. A dark-coloured substance is sometimes found in the stomach, and the upper part of the intestines is frequently inflamed.

Where the dose taken is very large, the stomach often presents an appearance similar to that produced by oil of vitriol. Oxalic acid does not seem to be a corrosive, though it is an irritant poison, perforation of the stomach is rarely produced by it. When a person has taken this poison, the best treatment is to administer lime in the form of chalk, or in solution in water mixed with oil. If chalk cannot be obtained, the scraping of the ceilings or walls may be administered, suspended in water. Lime in any form is the best antidote, as oxalate of lime is insoluble in water. Emetics may be administered with advantage, if the poison has not already produced sickness, and the stomach-pump should be resorted to, but care should be taken not to injure the throat, which has been rendered tender by the acid. The action of oxalic acid is so rapid that, what remedies are employed should be used quickly. Alkalies must not be given, as their oxalates are very poisonous. Death from the direct action of oxalic acid has occurred within twenty minutes, or it may be delayed for several hours. The secondary effects have not, in one case, proved fatal till after twenty-three days. Bin-oxalate of potash, commonly called "salt of lemons," is quite as poisonous as oxalic acid, the symptoms which it produces are the same, as also are the *post mortem* appearances which it leaves behind. Half an ounce of this salt is a fatal dose, and the treatment to be employed in no way differs from that recommended for poisoning by oxalic acid. In the solid form, it has been said that oxalic acid resembles sulphate of magnesia, it is also very like sulphate of zinc. In the mass, however, its crystals look more opaque than those of either of these substances. It is, however, easy to distinguish between them by the taste; oxalic acid is sour, magnesic sulphate and zinc sulphate are bitter—all three are soluble in water. If

ammonia solution be added to a solution of each of them, it will produce no apparent effect on the oxalic acid, but it will throw down a white precipitate in the solution of the zinc salt, which is soluble in excess of ammonia, and with the magnesia solution it gives a white precipitate, not soluble in excess, but which is dissolved by muriatic acid, from which solution it cannot be reprecipitated by ammonia. With caustic potash or soda dissolved in water, oxalic acid gives no precipitate, but both the other substances do; the zinc precipitate however being soluble in excess of the alkali. Heat also serves to distinguish between them; it completely dissipates oxalic acid, but only drives off the water of crystallization from the other two salts, so that a white powder is left behind.

Inasmuch as a solution of oxalic acid has a strong acid taste and reaction, it might be supposed that it contained oil of vitriol. This can be disproved by adding muriatic acid and chloride of barium, for no precipitate will be found if the liquid contains only an oxalate; whereas a white precipitate will be thrown down if a sulphate be present. Nitrate of silver gives no precipitate with an oxalate in a solution acid with hydric nitrate, and this proves that the acidity of the solution under examination is not due to the presence of hydric chloride. If copper and hydric sulphate be warmed with the acid liquid, red fumes of nitric acid will be given off if its acidity is caused by hydric nitrate. The best test for an oxalate is a soluble lime salt, the precipitate found is white and insoluble in water, but, as it is soluble, in what are called the mineral acids, before adding the lime salt to the solution to be tested, it should be made neutral or alkaline with ammonia. Oxalate of lime is insoluble in acetic acid, and this distinguishes it from other lime salts insoluble in water. Nitrate of silver has no very distinctive reaction with oxalates. In a neutral solution it causes a white precipitate, and when the precipitate is heated it detonates, and leaves metallic silver. In mixtures containing organic matter oxalic acid is easily detected; it does not form albuminates, nor does it in any way unite with organic bodies forming insoluble compounds. It is best to dilute the liquid in the mixture to be tested, then to filter it. Sometimes it is well to boil before filtering, and it may be desirable to pass it through animal charcoal if it be too highly coloured. To the filtrate acetate of lead should be added, and oxalate of lead will be thrown down. The addition of the acetate should be continued till no further precipitate is formed. The oxalate of lead should then be filtered off from the liquid, and well washed; after that it should be suspended in distilled water, and sulphuretted hydrogen

passed in till the lead salt is all decomposed. The decomposition which takes place is this, the sulphur of the sulphuretted hydrogen goes to the lead, forming lead sulphide, which is black, and the hydrogen takes its place in the oxalate, forming hydric oxalate (oxalic acid). The sulphide of lead must now be removed by filtration, and the liquid boiled to expel the excess of sulphuretted hydrogen dissolved in it; the boiling may be continued to evaporate the water, so that on cooling the liquid may deposit crystals. These crystals should be dissolved in distilled water, and be then submitted to the tests which have been described. If the lime reaction is employed, and it is the best, by way of confirmation, some of the precipitated oxalate of lime should be dried and heated to a dull red heat. By this means it will be decomposed, carbonate of lime, and perhaps some lime, being left. Both these substances are soluble in acetic acid, whereas the oxalate of lime is not. This confirmatory evidence is very reliable, as no substance but calcic oxalate will give these reactions.

Amongst the organic poisons, prussic acid is perhaps most generally used; its effects are very deadly and very rapid, from the small quantity required to cause death, and from the ease with which it can be taken or administered to others, it has been too frequently used by the suicide and poisoner. It will be remembered that not many months ago a whole family was poisoned in the neighbourhood of Smithfield with prussic acid, and the details connected with that case were so extremely painful that for a time it called public attention very particularly to this poison. The criminal records show that, next to opium, prussic acid has been more frequently used than any other poison for causing death. Dr. Guy states that in the years 1837-8, twenty-seven cases of poisoning by prussic acid came under the notice of the coroner; eight of these were suicides, and in each case the person was either a medical practitioner or a druggist. A short time ago the contents of a stomach were brought to the author for analysis; the poison found was prussic acid, and the suicide was a druggist. The ease with which the poison is procured by such persons, and the rapidity of its action, together with the knowledge which they possess of the apparently little suffering which it produces, no doubt causes it to be more frequently taken by them than by others who can only obtain it with difficulty, and who have no knowledge of its action.

Poison by prussic acid is, however, often accidental. The incautious use of substances which contain this poison has too frequently been the cause of death. The essential oil of bitter

almonds, used as a flavouring for confectionary, if not properly purified, contains prussic acid, and very serious consequences have arisen from its being employed too freely. It may, however, be freed from prussic acid, to which its peculiar pleasant flavour is not owing, by treating it with lime and ferrous chloride (protochloride of iron) and distilling the mixture. The leaves of the laurel (*prunus laurocerasus*), the kernels of plums, cherries, and peaches, and the pips of apples, contain prussic acid, and death has been caused by taking too large quantities of some of them. Prussic acid belongs to the class of poisons termed *narcotic;* their action is on the brain and spinal marrow. The peculiar symptoms of narcotism are produced most completely by opium, whereas prussic acid seems to affect the heart and lungs. Opium stands at the head of the list of narcotic poisons, but it will be briefly considered after prussic acid, or as it is sometimes called hydrocyanic acid, and more correctly hydric cyanide. Prussic acid is a compound made up of hydrogen and a gas called cyanogen, which is itself a compound of carbon and nitrogen. Cyanogen contains twelve parts by weight of carbon, and fourteen of nitrogen. It is a poisonous gas, and is usually prepared by heating mercuric cyanide; it is decomposed by water, forming ammonic oxalate, amongst other products. When collected over mercury and burnt, it gives a beautiful pink flame, and yields carbonic acid and nitrogen gases. Prussic acid is usually prepared by heating potassic cyanide with dilute hydric sulphate (sulphuric acid), or more commonly by using potassic ferocyanide instead of potassic cyanide. Potassic ferocyanide, generally known by the name of yellow prussiate of potash, is met with in well-marked yellow crystals; although yielding so poisonous a substance on its decomposition, it is itself harmless, and if, when swallowed, it has any action on the human frame, it is that of a mild aperient. The making of prussic acid is usually performed in a retort, and the volatile hydric cyanide is carefully condensed and collected in water. The pure acid, free from water, is made by passing the gas through a tube made in the shape of the letter U—this tube is filled with cyanide of potassium; a second U tube is employed, which is filled with chloride of calcium; the cyanide of potassium stops any hydric sulphate which might come over, and the chloride of calcium retains the moisture which accompanies the acid: to the chloride of calcium tube is attached a delivery tube, which dips into a glass flask surrounded by a freezing mixture composed of ice and salt, and in this vessel the pure hydric cyanide is collected. Prussic acid is rarely met with in this state, it is always diluted with water, and

preparations of it of various strength are used in medicine. Scheele's prussic acid contains four per cent. of the pure acid; but that prepared according to the directions of the pharmacopœia contains but two per cent. The aqueous solution decomposes, especially when exposed to light, and ammonic formiate is produced; the acid too is very volatile, and escapes readily if the bottle containing it be left open, so that, unless fresh made, ordinary prussic acid varies very much in strength. It may, however, be kept for a long time unchanged, if a few drops of hydric chloride (hydrochloric acid) be dropped into it; this action is not understood.

The odour of prussic acid is said to resemble that of the essential oil of bitter almonds; this, however, is an error, as oil of bitter almonds has the same smell when freed from prussic acid; its odour is sickly and very oppressive, and when once smelt is never forgotten.

Other salts of cyanogen, besides hydric cyanide, have been used as poisons, and amongst these cyanide of potassium is the most important. It is largely used by photographers, and is therefore more readily obtained than prussic acid, the hydrogen salt. It is, too, more dangerous, as its solution may contain a larger quantity of poisonous matter than either the acid of the pharmacopœia or Scheele's acid. Both prussic acid and cyanide of potassium produce similar effects on the human frame. The former is used in medicine, but in a state of great dilution; it allays pain and spasms, but if given in large doses it produces giddiness. It is often given in affections of the stomach to allay vomiting, and in cases of asthma, or where cough results from nervous irritation, it has a sedative action, and allays palpitation of the heart, especially when it arises from dyspepsia.

The vapour is sometimes employed to produce local action upon the lungs in chest affections; externally applied it allays irritation, but here it must be used in the dilute state. In large doses prussic acid acts as a violent and rapid poison, prostrating the individual at once; in a few seconds the symptoms come on, and in a few minutes death ensues, though there are cases on record where death has been delayed for forty-five minutes. After taking a poisonous dose, there is usually a short period of consciousness in which the person can perform voluntary acts. This fact is established beyond a doubt by cases recorded by Dr. Christison: "An apothecary's apprentice lad was sent from the shop to the cellar for some carbonate of potass; but he had not been a few minutes away when his companions heard him cry, in a voice of great alarm, 'Hartshorn! hartshorn!' On instantly rushing down stairs, they found him

reclining on the lower steps, and grasping the rail; and he had scarcely time to mutter 'Prussic acid!' when he expired, not more than five minutes after leaving the shop. On the floor of the cellar an ounce phial was found, which had been filled with the Bavarian hydrocyanic acid, but contained only a drachm. It appeared that he had taken the acid ignorantly for an experiment, and from the state of the articles in the cellar it was evident that, alarmed at its instantaneous operation, he had tried to get at the ammonia, which he knew was the antidote, but he found the tremendous activity of the poison would not allow him even to undo the covering of the bottle."*

Another case is also one of an apothecary's assistant, who was found dead in bed with an empty two-ounce phial on each side of the bed. The mattrass, which is used in Germany instead of blankets, was pulled up as high as the breast, the right arm extended straight down beneath the mattrass, and the left arm bent at the elbow. That voluntary acts can be performed after taking sufficient prussic acid to cause death, is of great importance in medico-legal investigations. A young man, assistant to a medical practitioner, was accused of administering prussic acid to a servant girl. She was found dead in bed, lying in a composed posture, with her arms crossed over her body, and the bed-clothes pulled smoothly up to her chin; at her right side lay a small phial, from which about five drachms of prussic acid solution had been taken, and the cork was replaced in the bottle, which was wrapped up in paper. Various medical men were examined as to whether the woman could have performed all these acts between the time of taking the poison and of her death. Dr. Christison was consulted on the case, and the jury acquitted the prisoner. In order to cause death, prussic acid need not be taken by the mouth, dropped between the eyelids it is equally fatal in its effects. When injected into a vein it acts even more rapidly, and placed on a fresh wound it is absorbed, and causes death. In whatever way the poison is administered, the effects produced are similar: they consist of tetanic spasms, giddiness, quick-catching respiration, rattle in the throat, dilated pupil, convulsions of the limbs, rigid contraction of the jaw, and the person dies either in tetanic convulsions or comatose. If the dose taken be small, but yet sufficient to cause death, the patient survives a longer time, and then salivation occurs with difficult breathing, and he dies generally from suffocation. In some few cases narcotic symptoms, similar to those produced by opium, have been observed. After death the appearance of the person seems natural, the countenance

* "Christison on Poisons," ed. 4, page 169.

is composed, but pale; the eyes have a glistening look, leading one to suppose that the life is not extinct. There is rigidity in the neck and limbs, often an odour of prussic acid from the mouth. On making a post-mortem examination, the smell of the poison is very marked on opening the cavities of the chest and abdomen. The blood is generally fluid, and the vessels of the brain are loaded with it; sometimes serum is found in the interior of the brain. The odour of prussic acid seems to hang about this organ, and Dr. Taylor says that it is even present where persons have died from natural causes. The bile is also said to have a blue colour; this was noticed by Mertzdorff. Putrefaction sets in rapidly, although it has been asserted that it is delayed by the action of this poison.

What is the smallest dose of hydrocyanic acid which will cause death? Less than one grain of the pure acid has caused death in an adult. More than eight minims are rarely given as a medicine, and half a drachm, or thirty minims of the pharmacopœia acid would no doubt produce very serious symptoms. The treatment to be employed where a person has taken prussic acid, is to administer that which will render the substance inactive, or which will act in a manner opposed to it. The time, however, which one has at one's disposal is so short, that remedies are rarely of much avail, unless applied immediately after the poison has been taken. Sometimes in the laboratory one gets slightly affected by this gas, and then the remedy is to take ammonia or carbonate of ammonia, which usually counteracts its effects in a short time. A medical gentleman noticed a goat on his lawn eating laurel leaves, after a time the goat fell down, evidently affected by the prussic acid; he quickly administered smelling salts, which are mainly carbonate of ammonia, and the goat recovered.

Mr. John Murray of London expressed himself willing to take a poisonous dose of hydrocyanic acid if an experienced person were with him to administer ammonia as an antidote. There is no doubt that it has a very rapid and beneficial effect; the ammonia should however not be used too strong. Cold water dashed on the head, on the face, and back of the neck, may have the effect of rousing the patient. Chlorine has also been used, and experiments on animals made with it seem to prove that it acts beneficially. Iron forms inert compounds with cyanogen, it has therefore been recommended as an antidote. When the patient has been roused to consciousness by ammonia and the cold douche, the best treatment seems to be to dry him carefully, use friction, and keep him warm. As soon as possible emetics should be administered, and, if necessary, the

stomach-pump may be used. The detection of prussic acid is easy, provided too great a time has not elapsed after death. The acid is volatile and easily decomposes, so that after a few days there would be little hope of finding it, if the quantity originally taken had been small. Before describing the method of detecting prussic acid in organic mixtures it will be well to give the reactions and tests by which it is discovered when it occurs without these complications. With nitrate of silver hydrocyanic acid gives a white precipitate, soluble in ammonia but insoluble in ordinary hydric nitrate (nitric acid). Argentic cyanide is however soluble in hot fuming hydric nitrate; in this respect it differs from argentic chloride, though it resembles it very much in appearance. When argentic chloride is heated to a high temperature it fuses, but heat decomposes argentic cyanide, cyanogen being driven off and metallic silver remaining behind in the vessel in which it was heated. Now argentic chloride is insoluble in hydric nitrate; if therefore it be heated with that acid liquid, after fusion, it is not dissolved, but the residue of argentic cyanide, after heating, is dissolved, for metallic silver is soluble in hydric nitrate, argentic nitrate being formed. If the substance under examination be potassic cyanide, when argentic nitrate is dropped slowly into it a white precipitate is formed, which is immediately dissolved by the excess of potassic cyanide. It is therefore necessary to decompose the potassic cyanide, and this is done by adding hydric nitrate in excess, potassic nitrate and hydric cyanide being formed. Hydric cyanide is, as has been stated, very volatile; if a few drops of the solution containing it be placed in a small Berlin dish, or if a few drops of potassic cyanide be taken and a little hydric sulphate be added, and the mixture be largely diluted with water; and then if a glass plate be moistened with argentic nitrate, and be placed so that the argentic nitrate is exposed to the fumes from the liquid in the dish, the volatile cyanide will form with it argentic cyanide, and a white substance will be seen on the glass plate; this is a very delicate reaction, and highly characteristic of prussic acid, as no other substance will cause it under the circumstances.

With mercurous nitrate hydrocyanic acid gave a grey precipitate of metallic mercury, whereas a soluble chloride gives a white precipitate of calomel. A very delicate and reliable test is that which is called the sulphocyanide test. It is performed as follows: A few drops of the cyanide are put into a Berlin dish with a small quantity of yellow sulphide of ammonia, and the mixture is evaporated to dryness in a water-bath. The dry residue is dissolved in alcohol,

and, when a drop of ferric chloride is added, a deep red coloured solution is formed, the colour of which is discharged by a solution of corrosive sublimate. In the first part of the process sulphocyanide of ammonia is formed; in the second sulphocyanide of iron, which is red; and in the last mercuric cyanide, which is colourless. The well known Prussian blue test, as it is termed, is not so trustworthy as the last, for the presence of ammoniacal salts in considerable quantities prevents the formation of Prussian blue. If this reaction is not obtained it does not prove that prussic acid is not present; but, if it is obtained, it is a most positive proof of the presence of that body. When yellow prussiate of potash in solution is mixed with a salt of the highest oxide of iron, Prussian blue is precipitated. Given prussic acid, it can be converted into yellow prussiate of potash by boiling it with caustic soda and protosulphate of iron, the liquid being alkaline with the soda, and care must be taken not to let it more than boil. When a liquid is submitted to this test, it is usual to make it alkaline with caustic soda, to add two or three drops of ferrous sulphate to gently warm it up to the boiling point, then to filter off the precipitate oxide of iron, and to add sufficient hydric chloride to make it acid, and afterwards a few drops of ferric chloride, when the blue colour will appear. When an organic liquid, supposed to contain prussic acid, has to be examined, the first thing to be done is to submit a little of it to the silver test, conducted as above described in a Berlin dish, over which is placed a glass plate moistened with argentic nitrate, some hydric sulphate having been added to the liquid. In the next place, some of the substance to be examined is mixed with hydric sulphate and distilled in a retort, and the distillate is collected in water, and to this aqueous solution the various tests, already described, should be carefully applied.

If prussic acid be present in but small quantities, it will be easily detected by these means. Another and very convenient method is to strain off the liquid from the solid part of the organic mass, and well wash it with distilled water, adding this to the strained liquid, then to add argentic nitrate, which will precipitate the cyanide, if any be present, along with any soluble chloride which may happen to be mixed with it. This silver precipitate should be filtered off and washed with distilled water; it should then be heated with ammonia, which will dissolve both the cyanide and chloride of silver. If this ammoniacal solution be neutralized with hydric nitrate, the two silver salts will be reprecipitated, and if, after careful washing, they are boiled with a solution of caustic soda they will be decom-

posed, argentic oxide will be precipitated, and cyanide and chloride of sodium will be in solution; but cyanide of sodium or cyanide of potassium dissolves cyanide or chloride of silver; therefore, if a cyanide was present in the original substance to be tested, some of either or both of these silver salts will be held in solution by the cyanide of sodium. Now, if the cyanide of sodium be decomposed by hydric nitrate, the silver salt will be precipitated. No other substance but a cyanide can give this reaction, and therefore it is both delicate and trustworthy.

OPIUM is a narcotic poison; it has been often used both by the suicide and murderer. In 1837—38, 200 cases of poisoning by opium occurred; of these 42 were by solid opium, 133 by laudanum, and two were cases of mixed poisoning by laudanum and prussic acid, and laudanum and aquafortis, and two were cases of poisoning by acetate of morphia. Of these 200 cases 64 occurred in children, and the remainder in adults; and of these 64, 41, or a fifth of all, were from overdoses of cordials or medicines administered to young children and infants by their mothers or nurses.* Opium is obtained from the capsules of the *Papaver somniferum;* they are gashed and the gum exudes; it is collected and made into masses, which are sent into the market. The best variety is genuine Smyrna opium. Its preparations, when employed with skill, serve as most useful medicines, but when taken in excessive doses they act as a deadly poison.

Opium, when taken in large doses, produces giddiness and an inclination to sleep, stupor supervenes, and the person lies as if in a profound sleep. He can be easily brought to consciousness in the earlier stages of the poison's action, but he as soon relapses into insensibility. His breathing is slow and stertorous like that of a person in apoplexy; his countenance becomes pale, his pulse slow, and after a time it is quite impossible to arouse him. Sometimes there is vomiting, and if this continue it indicates a hope of recovery. In opium poisonings the pupils are generally contracted. Generally the symptoms commence in less than half an hour after the poison has been taken, but sometimes not till an hour and a half. Death has occurred in three quarters of an hour, but some persons have lived for nearly twenty-four; the usual time is about nine or ten hours. When the fatal termination is delayed beyond this time, there is hope of the patient's recovery. The best treatment to be employed in opium poisoning is to use the stomach-pump at once, and to inject dilute stimulants, weak ammonia, water, and coffee.

* "Forensic Medicine," Dr. Guy, page 439.

Emetics may be used freely, warm water should be given, and the throat tickled. This may be done before the arrival of medical assistance. The patient should not be allowed to sleep, but should be kept awake by shaking, walking about, pinching, or in any way which may suggest itself. Cold water should be dashed on the head and face, and the soles of the feet tickled, the great object being to prevent stupor coming on. No part of the treatment is more important than this, for if lethargy be prevented there is good hope of recovery. Galvanism is sometimes resorted to. If the patient is sinking into the state of collapse, ammonia should be given, and ammonia salts held to the nose. Sometimes in this state artificial respiration is found to be useful. Post-mortem, the blood-vessels of the brain are found to be tinged, the blood is fluid, the stomach appears healthy, the skin is livid, and the lungs congested. The quantity of opium necessary to cause death varies; a man aged forty-five was killed by taking ten grains. The smallest fatal dose recorded for an adult is four and a half grains. Much, however, depends on constitution and previous habits. Those accustomed to take this drug may swallow as much as several ounces. Children are very easily affected by opium; a sixth and even an eighth of a grain has caused death in an infant four days old.

There are many substances, termed alkaloids, contained in opium, but our space will not allow us to consider more than one, and that the most important of them—it is called Morphia. Morphia is used in medicine as the acetate and as the hydrochlorate. Morphia is a whitish powder, not soluble, or very slightly soluble, in water. It also occurs in crystals. When heated it burns with a resinous flame, and it yields ammonia. Morphia dissolves in ether, and also more readily in alcohol. It is soluble in acids, and is precipitated by caustic alkalies, but is redissolved by excess of them. It has a bitter taste. When it is desired to discover if opium be present in organic mixtures, it is usual to test for morphia and for an acid which is contained in opium, called meconic acid, and with which it is combined as meconate of morphia. The tests for morphia are few in number; they are all colour tests, and on that account must be performed with care and by practised experimenters. The solution containing morphia should be evaporated to dryness on a water-bath, and the test applied to the dry substance. The perchloride of iron, when added to crystals of morphia, yields a blue colour, not bright, but rather dark and dull, resembling indigo. In a short time this blue changes to green. Hydric nitrate causes a deep yellow colour with this substance; the colour often approaches to orange. If some

crystals of iodic acid be dissolved in water, and be mixed with starch boiled in water, and then if a crystal of morphia be dropped in, around the crystal a blue colour will appear, the morphia reduces the iodic acid, setting iodine free, which causes the blue colour. If this test be performed improperly, the blue colour will not be obtained; if the morphia and iodic acid be mixed first, a yellow colour will be produced; but this is evidently not free iodine, as it does not change the colour of the starch. There is still one other test which is sometimes used, though it is not a reliable one, as other substances besides morphia produce the same effect; it is performed by adding strong hydric sulphate to crystals of morphia, and then a small quantity of a solution of bichromate of potash, the morphia reduces the chromic acid of the bichromate to the chromic oxide, and in doing so produces, first a brown, and then a green colour. The whole of these reactions, taken together, give very good proof of the presence of morphia. Meconic acid is a crystalline substance; the crystals are white, with a reddish tinge; it is soluble in water.

There is but one test for meconic acid, and it is a good one. The perchloride of iron gives a deep red colour with meconic acid; but it does so with a sulphocyanide, as was seen in testing for prussic acid. But the colour got by the sulphocyanide is discharged by a solution of corrosive sublimate, whereas that obtained with meconic acid is not; it is, however, destroyed by a solution of protochloride of tin. When morphia and meconic acid are found to be present in a liquid, there can be no doubt that it contained opium, unless, as is not likely to happen in a case of poisoning, they were specially put in by some one who was aware of their properties. In organic mixtures containing opium it is necessary to separate the morphia from the meconic acid, and this is done as follows: Acidulate the mixture with dilute hydric chloride, and allow it to stand for some days; then filter and evaporate the solution, add plumbic acetate, and it will carry down the meconic acid as meconate of lead. This should be filtered off from the liquid, which should be kept, and then suspended in distilled water, through which sulphuretted hydrogen should be passed, sulphide of lead will be thrown down, and meconic acid will remain in solution. The morphia, as acetate, is obtained by first precipitating from the filtrate the excess of lead by means of sulphuretted hydrogen, then filtering off the lead sulphide, and evaporating and treating with alcohol, which dissolves the acetate of morphia which can be obtained by crystallization from its alcoholic solution.

It has been the intention of the author in these articles to give

an idea of the action of those poisons best known to the general reader, as well as to show the methods adopted for discovering their presence. The chemical reactions of the various metals treated of have been stated pretty fully, as being more likely to interest and instruct the readers of THE STUDENT. It is not to be expected that all will be interested in such a subject, but it is hoped that what has been said will lead some to follow it up, if not from the medical, at least from the chemical point of view.

THE STATE OF SCIENCE IN ENGLAND.

IF the upper and middle classes of England were polled upon the question of the importance of a study of science in this country, an almost unanimous affirmative would be recorded. Perhaps at no time has there been so general an opinion that our industrial prosperity depends upon a knowledge of natural laws, and thus we have arrived at something like a national conviction that science may be made to pay. This frame of mind is very different from, and very much lower than, a love of science for the sake of truth, and as an aid to intellectual development. It tends to a certain demand for science teaching of a concrete kind—that is brought into direct contact with commercial or industrial life. The "technical education" cry is an illustration of this fact, and we commented upon it some time ago, showing the absurdity of tradesmen and manufacturers asking professors to teach their boys those bits of chemistry, botany, etc., which would give their services a commercial value as soon as they left school. The peculiar prejudice of the uncultivated rich and the ignorant poor in this country, in favour of what they call "practice," as better than what they call "theory," is exemplified in this demand; and it is only by slow process and with difficulty that, by the force of circumstances and by timely admonition, the value of pure science can be made known. We are glad to see that Professor Williamson, in an Inaugural Lecture, delivered at University College in October, and which he calls a "Plea for Pure Science," has taken up this important question, and placed it in a distinct light. Alluding to the two parties advocating science teaching, the so-called "practical" and the philosophical, he says:—

"One party looks to the special duties for which a young person has to be prepared, and the material difficulties which he is expected to encounter. They see that the success and happiness of each

individual are proportional to the efficiency with which he discharges the aggregate of the special duties of his station in life; and they accordingly recommend that each youth be placed in circumstances which may induce him to imitate accurately the doings of some one who is known to be successful in a station such as he is intended to occupy. The other party looks to the general qualifications which experience has shown to be most important for any success in life, and to the means by which they are most effectually acquired. They see that men who have been taught to understand and apply the best-known general principles, are able to master a given set of practical details with a facility and completeness which other men do not attain. They know that a general principle of nature is an instrument of thought applicable to the explanation of an infinite variety of phenomena, and they recommend that every one be placed in his youth somewhere where he may best learn such general principles. The first party takes little account of the development of the mental powers as a distinct object to be aimed at in education, the second attends but little to special business operations.

"The former recommends special or technical instruction with a direct view to material success in a particular business, the direct aim of the latter is to educate and strengthen each individual mind. The essential differences between them arise from the fact that they look at the question from opposite sides, and respectively put forward what they see most clearly. But those who go into the question from the practical point of view, soon come to see the necessity of some scientific knowledge, and those who go into it from the side of theory gradually come to practical considerations. What is wanted is a system satisfying the requirements of both parties.

"A purely practical apprenticeship or pupilage does lead a man to desire, and to some extent to obtain, a knowledge of scientific principles. He cannot get on in his practical operations without some such knowledge, and he manages to pick up bits of it in proportion as the want of them is urgently felt, gradually increasing his store of general knowledge in after life.

"On the other hand, those who have received instruction in general principles, accompanied by practice in the methods of their application to simple cases, have ample opportunities during their special pursuits in after life, for learning all the particulars of a business, and for improving its details.

"The special men leave to chance the acquisition of scientific knowledge, and the training of the mind. The men of science do

not take cognizance of the special conditions requisite for realizing success in each business. They observe and compare the means by which men attain the utmost usefulness in their practical pursuits, and perceive that the very great majority of such men have got certain habits of mind in common with one another, habits of mind which enable them to understand and control natural processes, in proportion as they become accurately and fully acquainted with the particulars of the processes in question.

"Men of detail do not sufficiently appreciate the value and usefulness of ideas, or of general principles; and men of science, who learn to understand and control things more and more by the aid of the laws of nature, are apt to expect that all improvements will result from the development and extension of their scientific methods of research, and not to do justice to the empirical considerations of practical expediency which are so essential to the realization of industrial success in the imperfect state of our scientific knowledge."

In this passage we find a fair statement of the facts of the case, coupled with the willingness on the part of this particular professor, which others share with him, to meet the "practical view," so far as concurrent with any scientific teaching really to be so-called. No set of people have such a narrow and incomplete view of what is "practical," as the "practical men." To their minds, that alone is practical which is put into serviceable and remunerative practice to-day; they have little thought for the morrow. "Sufficient for the day is the competition thereof," is their motto; and they do not perceive in the abstract ideas of one period the motive power which will control the daily work of a succeeding time.

An accurate survey of pure science would show that chance discoveries of importance are less likely to happen in the future than they were in the past. In many directions all such discoveries have already been made, and the next steps are only likely to be taken by those who have a distinct notion of what they are about, and who are well acquainted with the reasonings as well as with the facts at which their predecessors have arrived. If an inquirer skilfully pursues a line of thought, or a fertile suggestion, he is very likely to arrive at some result he did not anticipate, or which contradicts his expectations; but such discoveries are not properly chance incidents: they are part of the natural reward of pursuing a subject in a truly logical and intellectual spirit, and for the most part the merely practical man would not understand their indications when they occurred before his eyes.

Professor Williamson judiciously says, in reference to the efforts of imperfectly educated men to make new applications of science :—

"It would be a cruel deception to encourage such attempts. Many of them, however, do manage by their individual exertions to acquire some knowledge of scientific principles, and to get a part of what they want under peculiarly difficult and unfavourable conditions.

"But although a considerable amount of good and useful work is done by men whose intellectual excellences consist mainly in the habit of vigorously applying to a particular practical purpose a limited stock of ideas which they find near at hand, there are other qualities and powers which make themselves felt, and which accordingly claim our attention.

"There are men capable of modifying a system when new circumstances arise--of making arrangements to meet new wants in proportion as they are felt—and even of anticipating wants by devising new products, or better kinds of an old product.

"There are men also who penetrate beyond the knowledge given to them of the process of a manufacture, who make new observations and experiments relating to them, and who bring to bear on them knowledge acquired in other fields of work, or inventions which had been made for other purposes. The result of their influence is, that any manufacturer who keeps to his old system without gradual improvement, soon gets left behind. He may not realize this result for a while, but it never fails to show itself in time."

Part of the dislike which the ordinary middle class man has to pure science or to anything he calls "theoretical," arises from the circumstance that boys whose tastes and mental habits run strongly in favour of abstract truths of any kind, are seldom good for much in the factory or the counting-house, and each parent fears that his son may, by becoming a philosopher, be unfitted for work. A wider knowledge of the mental characteristics of our nation would lessen such fears. In the great majority of cases in which science is pursued, it will be found that the instinct to be practical prevails over any desire to be merely theoretical, and our social difficulty, with regard to science, is not that we have too many, but too few, who are willing to study it for its own sake, apart from its bearings on daily life. The really practical man could use more serviceable theory than the pure science man can evolve; and, if any class requires artificial cultivation for the benefit of the rest, it is that to which the man of pure science belongs. In the great majority of

cases scientific training does not give young men a distaste for practical life, though it certainly does make them dislike particular forms of it, conducted upon old habits and without thoughtful intelligence. The scientifically trained youth will not, if he can help it, go into an occupation where his knowledge is of no use, and in this he is quite right; but as one trade and manufacture after another rises in the character of its processes, his willingness to work in them is increased.

The nation has come naturally to a theoretical conclusion—that science should be generally taught; but are we really making any corresponding progress in getting it taught? This question certainly cannot be simply answered in the affirmative, and on the whole we fear we must admit, after due examination of the indications, that if the progress exceeds or equals the increase of population, it is still extremely slow. A short paragraph would contain the names of all the institutions in the three kingdoms that put forth a programme of scientific lectures of any real use, and in the great majority of even large towns no such thing is ever attempted. A single lecture on a scientific subject with a popular title, interpolated between comic recitation and an "oration" on some historico-political character, is all that nineteen-twentieths of our Literary and Scientific Institutions can venture upon. Artistic drawing fares better; and where the teacher is good, it is not uncommon to find the number of pupils large.

Of late years, Field Naturalists' Clubs and Microscopical Societies have multiplied, and must be doing good; but a very small portion of the members of such bodies ever dip below the surface, and most content themselves with learning the names of objects from somebody else, and examining them in an unscientific way. If we take another test of the progress of science, and inquire how many well-to-do families possess any scientific apparatus, and know how to use it, we shall again be convinced that the taste for science is very sparsely spread. A good deal has been done to link together science and recreation, but the capacity to be recreated by science is cultivated to a very slender extent. Anybody can be occasionally amused by a brilliant experiment, or by gazing through a microscope at a splendid object, or through a telescope at a grand group of stars; but the recreation obtainable from science by those who have never *studied* the elements of a single branch, soon comes to an end. Some books and some teachers make the road to knowledge much easier than others, but in spite of all help, no one can learn to think, in a scientific way, without undergoing a considerable

amount of preliminary toil, and very few will take the pains. There is much in our social life that is unfavourable to mental cultivation; our prodigious inequalities of wealth leave a mass too poor for anything but daily drudgery, and elevate a certain class, who, unhappily, serve as models for those below them, into habits of luxurious idleness with which science has not the slightest affinity. A man, who by force of genius and years of toil, arrives at the head of a department of science, is held in some honour, but very considerable attainments in science have a smaller action in securing respect than the acquisition of a sum of money by questionable means. Our scientific men, unless forced into prominence by special circumstances, are quiet, silent students, who exert little influence upon surrounding circles, and have few opportunities of spreading their tastes. This state of things cannot continue without imperilling our position amongst the nations, and the first people which materially surpasses us in average scientific culture, will take the lead and leave us behind. With our practical character, which, when misdirected, does so much harm, it is only necessary to get a subject of public importance well understood to ensure efforts in the right direction, and if those who influence the movements of society can be made to see our defects and deficiencies, we shall not have to wait long for exertions of a remedial kind.

OPTICAL PROPERTIES OF CHLOROPHYLL.*

The green matter of leaves, or chlorophyll, possesses the most varied properties, and is the cause of a very great number of phenomena. Some of these are not well understood, and offer an attractive and fertile subject of investigation. M. Hagenbach has considered chlorophyll solely as relates to its optical properties. These properties are shown in two characteristic forms—(1) *fluorescence*, by which the incident rays are transformed into rays of less refrangibility; and (2) *absorption*, by which one portion of the rays transmitted through chlorophyll are absorbed and disappear. M. Hagenbach's work, according to his own statement, only relates to the practical results of his observations, and he intends, after having studied in succession different fluorescent bodies, to compare them with each

* From "Archives des Sciences." Review of "Untersuchungen uber der Oplischer," etc. Ed. Hagenbach.

other, and to deduce from them some special theoretical considerations.

M. Hagenbach has studied the phenomena of fluorescence by projecting the solar spectrum on the surface of a vessel filled with an alcoholic or etherial solution of chlorophyll. All the different parts deviate from their first direction, so as to appear red, but the tint is not uniform throughout the whole length of the spectrum; he readily observes in it some bands of a lighter tint. These bands, seven in number, differing in breadth and intensity, represent the maxima of the fluorescent action. Their position is perfectly fixed and determined by their relation to the Frauenhofer lines.

The absorption spectrum is obtained by direct observation of the green solution with the spectroscope, and it exhibits a numerous series of bands intersecting the bright portions. These last are reduced to the left of line B to two bright bands between C and D, and a broader band between D and E, and a similar broad band between E and F. The spectrum, thus divided, exhibits seven absorption bands plainly visible, and corresponding with the seven maxima of fluorescence. The relation between the two phenomena is, according to M. Hagenbach, very evident. The absorption bands are due to fluorescence, which cause the rays to deviate from their normal routes, and gives them a different tint. The optical qualities of chlorophyll do not seem to be influenced by the source from whence it is derived: whatever may be the plant, the phenomena are the same; but the properties of the chlorophyll are somewhat modified in a solution which has been kept for some time, even when it has been carefully secluded from the light.

GLACIAL MARKS NEAR FONTAINEBLEAU.

BY M. E. COLLOMB.*

THE plateau of Brie may be represented by the space comprised within a triangle, one side of which is a line of 55 kilometres drawn from Paris to Fontainebleau, another of 80 kilometres from the latter place to Montmirail, and the third of 80 kilometres from Montmirail to Paris; the whole surface being about 2000 square kilometres. This plateau is composed of a series of level plains, in which rivers have dug valleys, whose mean breadth scarcely exceeds a few kilometres. Thus, in the west we find the Essonne, the Seine,

* From the "Arch. des Sciences."

the Yerres, the Great Morin, the Little Morin, and the Marne—the two last bounding the basin to the north. These waters flow about 40 metres below the level of the plateau.

The plateau is surmounted by knolls and hills, which vary its monotony, and rise sometimes in isolation in the middle of the wide plains, above which they are elevated only about 140 to 150 metres. The rivers have a mean altitude of 40 metres, the plateau of 80 metres, and the hills 150, being the highest points of the district. The general slope of the soil is slight, though the Seine at Fontainebleau is 42 metres (above the sea), at Paris 30. On the north the slope of the plateau is not so great. All the rivers have a general tendency to the north-west, and the furrows and abrasions of the quarternary period follow the same direction. These denudations may be traced beyond the plateau, passing Paris, and extending to the sea, passing by the country of Bray.

The geological character of this plateau is well known. The upper chalk which forms the base of the Paris basin is not visible in any part of it, and the tertiary series is not complete—its inferior members, the plastic clay, the *calcaire grassier*, and the Beauchamp sand, being wanting. In the deposits from the denudations we find the workings from the lacustrin chalk of St. Ouen, surmounted by the green marls of Montmartre, and the plateau itself is formed exclusively of the chalk or travertin of Brie, covered thickly with alluvium, and forming a first-class agricultural soil. The isolated hills are of the sandstone or sand of Fontainebleau, in general the sandstone forming the cap of the hill and the sand its base. Above the Fontainebleau sandstone, which is exclusively marine, there is a final deposit, the chalk, or *meulière lacustre* of Beauce, which in this district is only found in strips, and it is only southwards, near Orleans, that it is well developed. All these deposits are in a horizontal position, and up to the present time no faults or dislocations have been discovered.

On one of the sandstone hills we saw *surfaces moutonnées*, and striated exactly as is shown where ancient glaciers have left their traces. These striæ were first observed by MM. Belgrand and Jacquot, engineers, visiting the works executed on this plateau to conduct the water of the Vaune to Paris, and they appeared so inexplicable to these philosophers that, after having communicated the fact to the Geological Society on the 4th of April, 1870, M. Belgrand persuaded his colleagues to visit the spot, to observe and confirm or confute the existence of glacial striæ in the neighbourhood of Paris. The place we visited is named Padoe, and is

14 kilometres south of Corbeil, and 8 west of La Ferté-Aleps. It is a sand hill, 132 metres in elevation, composed of sand and Fontainebleau sandstone, the sand occupying the lower position, and the sandstone making a cap surmounted by strips of the *Calcaire de la Beauce*, all resting on the travertin of Brie, 79 metres high from the foot of the hill. Its height above the plain is thus 53 metres. The summit of the hill, sensibly horizontal, has an undulating, and one might say *moutonnée* character, such as Saussure observed in the Alps. The surface is stripped of its covering of turf, peat (*terre de bruyère*), or red alluvium, for a space of 50 or 60 metres, where the workmen quarry the sandstone. This surface, without examining it with great attention, is seen to be furrowed with numerous parallel striæ, sometimes close to each other, and sometimes several centimetres apart. This length often exceeds 50 or 60 centimetres, but is sometimes less, and always follows exactly the undulations of the surface, exactly like the striæ observed on rocks scratched by glaciers. When this sandstone is traversed by fissures the striæ are sharply interrupted at the edge of the gap, and resume their normal direction as soon as it is passed, and when it is covered by the lacustrine chalk they disappear. Their mean direction is towards the north-west, so that the motive force producing them must have acted from S.S.W. to N.N.E.

Another example may be seen at three kilometres from Fontainebleau on another sandstone hill belonging to the same mass by the village of Champceuil. On exploring an old and abandoned quarry, we noticed on the top of the escarpment forming its margin a series of striæ similar to those just described. The sandstone forms there a little denuded plateau, almost horizontal, but slightly undulated like the last; and on the south side it bends abruptly, and on a steep footway (*couloir*) narrowing towards the bottom, and widening upwards, the striæ are sharply defined. They ascend up the walls of the path, and open fan-like towards the top of the escarpment. The direction of these striæ is towards the north-east.

Thus we noticed the appearances at two points, but the workmen of M. Belgrand engaged on the aqueduct of the Vanne, tell us that they are found on a great number of hills in the forest of Fontainebleau and its environs, and MM. Julien and Roujou having made a fresh exploration of neighbouring localities, have discovered similar markings at many places.

Geologists who have observed striated rocks in the Alps will not see any sensible difference between those and these, and, in my opinion, only glaciers could produce such phenomena; but if glaciers

did exist in this part of France, where are their moraines? The reply is easy. On such a glacier there could neither be superficial nor frontal moraines; it could only drag along with it a bottom moraine, a deep one. Median and lateral moraines only exist on glaciers which are dominated by lofty peaks; such deposits are only formed by the concussions and rubbings of the glacier on the walls which shut it in. Here the local configuration is opposed to such action, and no part of the glacier was encased. If we prolong the line of the direction of the striæ towards the south-west, it passes by Orleans, Poictiers, etc., and in no part meets high mountains. There is then no cause for astonishment that we do not find morianes, for if we take into account the relief of the soil, they could only exist in exceptional cases. That if superficial moraines did not exist, deep moraines could nevertheless displace and transport considerable masses of materials, without giving them that definite form of dyke or barrier that is ordinarily called a moraine.

I may add that the striated cakes, which have been called the characteristic fossils of glaciers, are not rare in the deposits of transported matter, in the drift of the valleys and plateau, and they are specially found in the diluvium of Montreuil, where M. Belgrand discovered a great many quaternary mammals.

The direction of the striæ does not correspond with the phenomena that fashioned the actual relief of the country; the rivers, valleys, and denudations of the plateau of Brie have a mean direction towards the north-west, and the striæ run to the north-east in a direction almost perpendicular, from which we may conclude that the valleys did not exist when the striæ were produced, because glaciers, whatever may be the form, move in accordance with the relief of the island; they flow like rivers, following an existing valley way. If the valleys of the Seine, the Essonnes, etc., had existed at this period, the glaciers would naturally have taken a north-western direction. The relief was different from what it is now, and their data thus goes back to the commencement of the quaternary epoch, or perhaps to the end of the pliocene.

THE POISON OF THE SCORPION.

BY M. JOUSSET.*

The scorpion has at all times excited the curiosity of naturalists. Sufficiently common in the south of Europe, where its sting is considered equal to the bite of venomous serpents, it has often been the object of study. Aristotle, Pliny, and Galen reported strange fables concerning it; and later, Fabricius, Redi, Swammerdamm, Vallisneri, Leuwenhoek, etc., and especially Maupertuis, Amoureux, Guyon, and Blanchard experimented on its poison, but without taking precise notes of its action.

Of the numerous species of scorpion distinguished by naturalists, three only deserve to attract our attention, because they inhabit the south of France and Africa.†

The *Scorpio Europæus*, a small species (0m ·03), is common enough in cellars, and among the rubbish of old walls, and its sting is insignificant, on account of the very small quantity of its poison.

The *Scorpio Oceitanus*, which is bright yellow, and somewhat larger (0m ·07), is found in the country crouching under stones. It is not common, and its sting is often followed by formidable consequences.

The *Scorpio Afer*, native of Asia, is tolerably common in Africa, and attains a size of 0m ·12 or 0·15, and its sting is certainly fatal ‡ to man. I have not been able to procure this species, and it is the *Scorpio Oceitanus* which forms the subject of this paper. The venomous apparatus of the scorpion is situated at the extremity of the caudal appendage. It is ampulliform, terminating in a black, curved, very hard and sharp spear, pierced near the point by two little holes, which allow the outflow of the poison accumulated in the thick part. The animal uses it in defence, and to kill his prey, and if it is only a poor fly, he pricks it before conveying it to his mouth. Its death is instantaneous. With large animals, dogs, rabbits, etc., death occurs after a longer or shorter interval, according to the quantity of the poison injected.

The poison is liquid, colourless, and limpid, distinctly, and like all venoms, soluble in water in all proportions, slightly soluble in

* "Comptes Rendus," 5th Sept., 1870.

† This limitation savours more of national egotism than philosophy.—Ed. S.

‡ M. Jousset's phrase is "La figûre est certainement mortelle pour l'homme." Would it not be more correct to say, *is sometimes fatal?* Ed.

alcohol, insoluble in ether, and of a density a little above that of water.

Microscopical examination shows it to be perfectly transparent, containing here and there epithelial cells and fine granulations, the presence of which is not constant. The quantity of poison contained in the ampulla is very small; it may be estimated at about two milligrammes for a scorpion of moderate size. Its activity is very great, and even this quantity is sufficient to cause the rapid death of a middle-sized dog.

The complication of phenomena occasioned in the upper organisms by the poison make it difficult to follow its action; but in frogs and *rainsettes*, whose interdigital membrane is thin, we can observe the effects very distinctly if we regulate the dose. Those who wish to repeat these experiments will find it useful to employ *Lilla viridis*.

The first experiments I made showed that frogs succumb rapidly under very small doses of the poison of the scorpion. Death comes on without convulsions. The skin of the creatures constantly assumes a violet tint, and seems injected.

In one of the experiments detailed the thigh of a green frog was innoculated with 0·0004 gr. of fresh venom, the member being arranged to show the circulation under a microscope. In two minutes the characteristic colour appeared. The circulation of the blood became sensibly slower. The calibre of the capillaries, measured exactly, remained the same throughout the whole experiment. In five minutes in one capillary, in the midst of normal globules, others deformed, elongated, and accompanied by other adherents were noticed. In proportion as the circulation slackened this appearance became more striking. One deformed globule, escorted by others adhering, arrived at the branch of a capillary, and obstructed both passages. By a movement of the animal a healthy globule slipped by, carrying with it a filament detached from the deformed globule. In the first capillary, where the globules were very numerous, they rolled on slowly, and in agglomerations of five or six. In ten minutes the globules became stationary, and obstructed the capillaries. From time to time a slight movement was made backwards and forwards, but it was transient, and nothing came of it.

In thirty minutes muscular rigidity was apparent in the limb. All the capillary vessels were filled with red globules heaped up together. Sensibility remained quite active, pain was manifested when the muscles were excited by a feeble inductive current,

which, however, caused no movement of the globules. The rigid muscles contracted feebly; the motor nerves were excited. This frog, the author tells us, recovered, as the quantity of poison was not enough to kill it, but the next morning it moved with difficulty, and with spasmodic action of the muscles. The leg that was pricked did not recover for several days from an indecision in moving.

In another experiment some frog's blood was put under a microscope, and brought in contact with the scorpion poison. In ten seconds the globules so acted upon "rounded," their contour became "absolutely linear," and they resembled little gelatinous masses. When the instrument was inclined the sound globules glided down, but the injured ones adhered to each other and to the glass. The red globules only seem to be affected.

MODERN ECLIPSE OBSERVATIONS.

BY JOHN BROWNING,

Member of the Council of the Royal Astronomical Society.

UNTIL ten years ago the instruments required for making observations during a solar eclipse, were few, simple, and inexpensive. A telescope of moderate aperture, furnished with some coloured screen-glasses of different intensities, and some thermometers to register the rapid decrease of temperature which occurs during totality, were all that it was considered necessary the intending observers should be provided with. Under such circumstances, observers thought principally of the spectacle presented by our great luminary during the time of totality, and of the changes which occur rapidly in the landscape with the rapid diminution of light. No idea was then entertained by even the most sanguine astronomer that the physical conditions of the sun could be discovered during the occurrence of one of these phenomena; the utmost that was hoped for being, that careful observations of the extraordinary appearances which presented themselves might throw some light on the meaning of the red flames then called "Bailey's Beads," which had been previously seen projecting beyond the moon's limb during totality.

In the great eclipse which occurred in 1860, both Mr. De la Rue and Father Secchi obtained photographs of the sun during

totality. A comparison between these photographs showed that, at an interval of seven minutes, the prominences observed at the two stations were identical. From a careful examination of his own photographs, Mr. De la Rue found convincing evidence that the red flames belonged to the sun.

The eclipse which occurred in India on August 17, 1868, was the first from which great results were obtained. Colonel Tennant having received a grant from the Indian Government, and some valuable assistance from the Royal Astronomical Society, took out to India a 9¼ inch reflecting telescope, equatorially mounted, with clockwork driving apparatus, and a very complete set of photographic apparatus. With these he succeeded in obtaining six photographs during the 5 min. 38 sec. the totality lasted. One of the prominences which appears in the whole of these photographs was very remarkable, on account of its size and peculiar configurations: it was of a spiral form, and the height could not have been less than 60,000 miles. It was formed by two jets of vapour which met at about 16,000 miles high, and produced the spiral arrangement. The colour of this protuberance was a delicate rose pink, streaked with silver. By the aid of a spectroscope, still more important results were obtained. The red flames, or solar prominences, when viewed by the aid of a spectroscope, gave a spectrum which consisted only of bright lines, and thus it was determined that they really consisted of enormous masses of incandescent gas; as the two principal lines corresponded with the lines C and F, it was evident that the gas of which they consisted was hydrogen.

Colonel Tennant says in his valuable report, published in the memoirs of the Royal Astronomical Society:—

"The great horn certainly was composed of incandescent vapours, and probably all the brilliant protuberances are the same. In the great horn these vapours were hydrogen, sodium, and magnesium. It seems to me perfectly certain that the ignited hydrogen issued from the sun itself, and that it carried up with it the light vapours of sodium and magnesium far above the level at which they would naturally lie; hydrogen, naturally, would be the very highest of the gaseous vapours, and consequently the coolest. If, however, it were set free at the surface of the sun, it would be intensely hot, and seek, with great violence, to ascend, in which process, if there be a stratum of heated vapours, such as is usually believed to exist round the sun, the hydrogen would partly displace and partly carry up these vapours, and the lighter would be taken in preference."

It occurred to M. Janssen, a distinguished French philosopher,

who made the same spectroscopic observations of this eclipse, that the spectra of these prominences might be obtained when the sun was *un*eclipsed. This proved to be the case, and during the very next day M. Janssen was so fortunate as to obtain evidence of the value of this suggestion.

Before the news reached England of M. Janssen's discovery, Mr. Lockyer had tried successfully the same experiment, and had been able to map out the forms of the prominences by the position and direction of the bright lines, which he saw when sweeping round the limb of the sun.

Soon after this, Dr. W. Huggins found that by opening the slit of the spectroscope widely, and viewing the spectrum through a red glass, the prominences themselves were rendered visible. By using a more powerful spectroscope, Mr. Lockyer was able to see them without the assistance of a coloured glass; so that now, by using a very powerful spectroscope, containing a train of not less than six prisms of the densest flint glass of 60°, the prominences when they exist may *at any time* be easily seen, drawn, and measured.

Speaking of this method (the broad slit of a powerful spectroscope), Mr. Lockyer says:—

"The solar and atmospheric spectra being hidden, and the image of the wide slit alone being visible, the telescope or slit is moved slowly, and strange shadowy forms flit past, the smallest details of the prominences, and of the chromosphere itself, are rendered perfectly visible, and easy of observation."

The study of these prominences, by the aid of the spectroscope, has yielded some most interesting and valuable information on many questions of solar physics.

Janssen describes a prominence which was more than 80,000 miles high; in appearance it resembled the flame of a forge fire driven out with violence through the openings in the coals, by a strong blast: another protuberance near it presented the appearance of a mass of snowy mountains, with the base resting on the limb of the moon, and lighted by the setting sun.

In one of his papers to the Royal Society, Mr. Lockyer says:—

"Here one is reminded by the fleecy, infinitely delicate cloud films, of an English hedgerow, with luxuriant elms; here, of a densely intertwined tropical forest, of intimately interwoven branches, threading in all directions, the prominences generally expanding as they mount upwards, and changing slowly—indeed, almost imperceptibly."

During the last two years, Lockyer, Zollner, Respighi, Secchi,

and Young, using very powerful spectroscopes, have carried on their researches on the solar prominences, and have published papers, which have greatly increased our knowledge of the cause of these phenomena.

In conjunction with Dr. Frankland, Mr. Lockyer has studied the spectra of gases under varying pressures, and has shown that the variation in the breadth of the lines in the spectra of the prominences is produced by the difference of pressure in the burning hydrogen, of which the prominences are principally composed.

Secchi has shown that there is an intimate relationship between the solar prominences and sun-spots..

As well as the prominences, there is a narrow line of red matter encircling the sun's disc, and therefore enveloping the whole solar surface.

Mr. Proctor has suggested that this consists of the same matter as the prominences; that it may be thickly studded with prominences of comparatively low elevation; and that the tops of prominences, both before and behind the sun's limb, would help to form part of it.

The small space at my disposal prevents me from doing any sort of justice to this part of my subject.

By the time this number of the STUDENT appears, Mr. Proctor's new work on the Sun will be published. As I have had the privilege of reading the proof sheets, I can confidently recommend the work as containing full information on all the topics I have touched on, set forth in that admirably lucid manner for which Mr. Proctor is so well known and so justly celebrated, and illustrated copiously with diagrams, in the construction of which Mr. Proctor has no rival. The theory of eclipses is also explained in a novel way, so clearly that any person may understand *why* they occur at stated periods.

For the eclipse observations of 1868 Colonel Tennant gave great attention to the preparation of a polariscope, for the purpose of determining the amount of polarized light in the corona, and, if possible, the direction of the plane of polarization. The results obtained have not enabled us to form any very decided opinion on this branch of the subject.

To observe the solar eclipse of 1870, Lord Lindsay has taken to Cadiz a 12¼ inch reflecting equatorial, with clock-work driving apparatus, with a set of photographic apparatus contrived by the writer. This apparatus is made on a breech-loading principle, and is so contrived that it can be worked by two persons; an assistant

will prepare the plates and place them in at the lower end of the apparatus, which will contain three prepared plates at the same time, while the operator will expose them and take them out, near the mouth of the telescope, and pass them on to be developed. Working in this manner it is hoped that three or four successful photographs may be obtained in about the space of a minute and a half, and in the remaining time, about forty seconds, it is intended to give one plate a much longer exposure, to try to obtain an image of the corona. Lord Lindsay has with him Mr. Davies, a skilful professional photographer, and an engineer to superintend the erection of his powerful apparatus.

A few extracts from instructions to observers, issued by the Organizing Committee of the Royal and Royal Astronomical Societies, will perhaps furnish the best idea of the character of the apparatus required to carry on successfully eclipse observations.

Instructions to Polarizers:—

"Observers are instructed to provide themselves with a double image prism; a Savart's polariscope; a plate of quartz, consisting of two compensating wedges.

"A plate of arragonite, or calc spar, cut perpendicular to an optic axis, and affixed to an analysing prism.

"A polarimeter, consisting of four plates of glass, movable on an axis perpendicular to the plane of polarization.

"A compound plate of right and left-handed quartz."

The work of the polarizers is divided into four observations. The first is intended to determine the polarization, if any, of the chromosphere, together with the direction of the plane of polarization.

The Nicol's prism of the polariscope should be set beforehand with its principal plane (or plane of symmetry) radial, *i.e.*, perpendicular to the sun's limb, and the observer must note whether bands are visible; and if so, whether they are black-centred, or white-centred. Should the bands be feeble, it will be well to rotate the polariscope, prisms and plates of course moving together, and quickly restore it to its primitive azimuth, after having noted the estimated azimuth of the Nicol when the bands are strongest and black-centred.

If time permit, the observer should try whether there is any sensible quantity of polarized light on the dark disc of the moon, rotating the analyser and determining the plane of polarization.

The second observation is to differentiate, if possible, between the corona and the chromosphere.

The observer should turn the analyser so as to extinguish, as far as may be, the light of the corona in the neighbourhood of a radius depending on the angular position of the analyser. He should notice the form, colour, and general appearance of any residual luminosity other than the well-known protuberances, and should contrast the appearance, especially as to colour, with that seen when the light is analysed, so as to retain light from the same region polarized in the perpendicular direction.

The third observation is to test the streamers from the corona as to polarization.

The fourth observation is for the purpose of determining whether the polarization observed in the corona is due to a secondary illumination of an intervening portion of the earth's atmosphere; that is, to the illumination produced by reflection from clouds towards our horizon.

Observers were particularly desired to test the object-glasses of all the telescopes intended to be used in polariscopic observations, for polarization which might arise from defects in annealing the glass.

Instructions for the spectroscopic observation of the chromosphere, and the base of corona, and the corona itself.

"To determine if there exists cooler hydrogen above and around the vividly incandescent layers and prominences. To do this the band of the spectrum just above the stratum which gives the hydrogen lines before totality, and during totality, should be carefully examined, to notice (*a*) if any traces of the hydrogen spectrum exists above the region which before totality gave the hydrogen lines; and (*b*) what lines extend outside the hydrogen spectrum, and whether they also exist with it in the lower strata.

"To determine whether any other gases or vapours are ordinarily mixed up with hydrogen, but remain invisible with the uneclipsed sun in consequence of the absence of saliently brilliant lines in their spectra."

To observe the chromosphere, a very powerful spectroscope must be used; for this purpose Mr. Lockyer is provided with an automatic spectroscope, contrived by the writer, and lent for the purpose by Mr. Gassiott; while Dr. Huggins has a similar instrument, lent for the occasion by Mr. Spottiswoode. These instruments have an arc, on which is distinctly marked the positions of the principal lines in the solar spectrum. As they are self-adjusting, the whole of the prisms are arranged automatically at the minimum angle of

deviation, for any particular line, when the zero is brought to coincide with that line, as marked on the arc of the instrument.

For observing the corona, spectroscopes of a totally different kind have been provided. In these instruments, only the low dispersive power of a single prism is used, with a very long slit, to embrace as much of the corona as possible, and an eye-piece of large field, and low magnifying power. For Mr. Lockyer's use, the writer has attached such an instrument as has been just described, to a $9\frac{1}{4}$ in. reflecting telescope.

Some apprehension has been entertained that the light of the corona may not prove to be sufficiently powerful to yield a good spectrum,* and it is hoped by the provision made for gathering light in the apparatus just described, that a satisfactory spectrum will be obtained.

Independent of Lord Lindsay's expedition, which he has carried out entirely at his own expense, there will be four parties of eclipse observers. These will be placed respectively at Cadiz, Gibraltar, Oran, and Sicily. The party which proceeds to Sicily will number in its ranks, Mr. Brett, the distinguished artist, and Mr. Brothers, the well-known photographer. Mr. Brett purposes to make a sketch of the corona. Much information may be hoped for from sketches, and the eye observations which Dr. Huggins will make, as the results yielded by spectrum analysis may be susceptible of various interpretations. Mr. Brothers proposes to confine his endeavours solely to obtaining photographs of the corona—exposing the plates so long as to overdo the other portions of the picture. Mr. Brothers will use a long focus portrait lens, mounted on an equatorial telescope—the image produced will be very small; but it may be viewed through a microscope, or larger photographs taken from it by the enlarging process.

Had time permitted, more complete apparatus would have been provided. The results obtained by the various parties will be looked forward to with great interest by all who have interested themselves in astronomical science.

Since the above was written the following telegram has been received from Lord Lindsay:—

"PUERTO, *Dec.* 22 (1.5 P.M.)

"Photographs successful. Two good pictures of corona.

"Polariscope doubtful; sketching good; spectrum no lines; broken sky."

* I do not share this apprehension myself, because with a small hand spectroscope I have readily seen the spectrum of the aurora borealis where the light was not visible to the naked eye.

GLANCES AT NEW BOOKS.

The study of natural philosophy is of primary importance in any good system of education, and notwithstanding the existence of many good books in our language, original and translated, we cannot say there is not room for more. Some works that will answer well as text-books in the classes of a judicious teacher, throw upon him the entire task of teaching the pupils how to think; for it is quite possible for a student, with a fair memory and a moderate knowledge of mathematics, to go through a course of instruction and be competent to pass ordinary examinations, and yet to know very little of the subject. Arnott's old and well-known "Elements of Physics" has stood its ground to the present day because it possesses in a high degree the qualities of logical exposition and suggestion. From the first part of Deschanel's "Natural Philosophy,"* edited by Professor Everett, we should accord similar praise to this work, which is adapted to more advanced students. In addition to being a good class-book, it is well adapted for private reading, as the style is good and the examples remarkably well chosen.

Another good educational work, though of a more strictly technical character, is "The Elements of Mechanism," by Mr. Goodeve, which now appears, "rewritten and enlarged" from previous editions.† This is an excellent treatise on the practical methods by which machines apply motion in any direction that may be required. The most casual observer of any complex machine in action must perceive that the object of its various parts is to convert the prime motion by which it operates into other sorts of motion, varying in direction, velocity, continuity, or intermission. The various contrivances, cranks, pulleys, wheels, trains, etc., etc., by which these modifications are effected are succinctly explained by Mr. Goodeve, and the formulæ given for computing the results. It is especially a book for practical mechanicians; but its simpler problems should form part of ordinary education. Mr. Goodeve writes for a

* "Elementary Treatise on Natural Philosophy," by M. Privat Deschanel, formerly Professor of Physics in the Lycée Louis le Grand, Inspector of the Academy of Paris. Translated and edited, with extensive additions, by M. J. A. Everett, M.A., D.C.L., F.R.S.E., Professor of Natural Philosophy in the Queen's College, Belfast. In four parts. Part I.—Mechanics, Hydrostatics, and Pneumatics. Illustrated by 181 engravings on wood and one coloured plate. (Blackie and Son.)

† "The Elements of Mechanism; designed for Students of Applied Mechanics," by T. M. Goodeve, M.A., Lecturer on Applied Mechanics at the Royal School of Mines, and formerly Professor of Natural Philosophy in King's College, London. (Longmans.)

somewhat advanced class of students undergoing what he terms "systematic preparation;" but the book is capable of wider use, and might be advantageously placed in every library to which workmen have access. It belongs to Messrs. Longmans' series of "Text Books of Science."

Another of the "Text Books of Science" is Mr. Bloxam's treatise on the "Metals, their Properties and Treatment,"* and we find that it condenses into a small space a good *résumé* of the metallurgy of iron and steel, copper, tin, zinc, lead, silver, gold, mercury, platinum, palladium, antimony, bismuth, aluminium, magnesium, and cadmium. It is well illustrated with numerous sketches of furnaces, apparatus, etc., and supplies a large body of practical information. On looking over a work of this description, we cannot avoid being struck with the fact that our great and remarkable advances in metallurgy have only prepared the way for further discovery and invention, and if a considerable number of our young men could be induced to acquire a sound scientific education, they would find openings in abundance for their talent and skill. For example, in speaking of iron ores, Mr. Bloxam mentions that the well-known pyrites, used, we believe, extensively as a source of sulphur, is not worked for the metal, the reason being the difficulty of getting all the sulphur away. The slag produced in enormous quantities is still only very partially used in economic purposes, although good specimens have been melted and cast into articles of considerable beauty. The difficulty lies in getting rid of sulphur and other damaging impurities, and this will no doubt be accomplished some day. Bessemer's process of blowing air through molten cast iron, and thus burning away the carbon to a greater or less extent, according to the prolongation of the operation, has done wonders for the trade and for public utility, but in its present form it is only applicable to good qualities of iron, and those which contain much sulphur and phosphorus cannot be advantageously employed. In Mr. Heaton's plan, nitrate of soda supplies the oxygen, and it is said to be efficacious in removing sulphur and phosphorus. Mr. Bloxam speaks of this plan as not yet sufficiently tested. If we pass from iron to copper, we find still much to be done, and we do not know that anyone has yet applied to any useful purpose the alloy of phosphorus and copper made sometime since at

* "Metals: their Properties and Treatment," by Charles Loudon Bloxam, Professor of Practical Chemistry in King's College, London, Professor of Chemistry in the Royal Military Academy and in the Department of Artillery Studies, Woolwich. (Longmans.)

Woolwich, highly spoken of for hardness and tenacity. There is no one metal in the use or working of which improvements are not required, and metallurgy must be pronounced to be a hopeful branch of applied science for any student anxious for commercial success to take up. Mr. Bloxam has epitomized and selected with judgment. Dr. Percy's loose and voluminous work leaves much to be desired, and it was no easy task to compress the most useful matter into one small book.

Dr. Alleyne Nicholson has just brought out the best "Advanced Text-Book of Zoology" that has yet appeared. It is of small bulk (pp. 240), well arranged, and illustrated with a considerable number of woodcuts. A careful reader will learn from it more of the principles of scientific classification, and get a better notion of the anatomical and physiological considerations on which it depends, than from any similar work we could name. It is a good book for private study and reference, as well as for class-teaching. It is written in a pleasant style, and we notice no serious faults. It is, however, scarcely correct to say that the bodies of infusoria "usually consist of *three distinct*, layers." The cuticle is, in most, easily distinguishable from the softer internal portions, and may, therefore, be termed distinct; but there is no line of separation or distinction between the so-called second, or cortical layer, and the softer part which lies next to it. The passage from one to the other is gradual. Again, it is better to say that no structure is observable in the cuticle than to call it *structureless*, which we have no right to affirm of any formation, upon the purely negative ground that our instruments fail to show how and of what sort of parts it is composed. There is a good glossary at the end of the book, and altogether it is one we can safely recommend to a wide and general use. It would be extremely valuable to have this book read in the upper classes of good schools. Any intelligent teacher could learn from it quite enough to offer necessary explanations; and the way in which Dr. Nicholson works up his facts so as to illustrate principles, places his book far in advance of ordinary manuals, and would ensure pupils being interested in his teaching.

Microscopists will never be tired of diatoms, and we have no doubt they will welcome Dr. Donkin's natural history of this interesting family of plants,† although it is too early to say to what extent they

* Advanced Text-Book of Zoology for the Use of Schools. By H. Alleyne Nicholson, M.D., D.Sc., M.A., Ph.D., F.R.S.E., etc., Lecturer on Natural History in the Medical School of Edinburgh, Vice-President of the Geological Society of Edinburgh, Author of "Manual of Zoology for the Use of Students," "Geology of Cumberland and Westmoreland," etc. Blackwood and Sons.

† "The Natural History of the Diatomaceæ," by Arthur Scott Donkin, M.D. Illustrated by coloured plates by Tuffen West. (Van Voorst.)

will agree with the new views he may propound. The first part now before us opens with the Naviculæ, which he very properly makes to include the Pinnulariæ, separated on insufficient grounds. Future parts, like the present one, will be illustrated by four plates, drawn by Mr. Tuffen West, the most skilled artist for this difficult sort of work. This work, when finished, will consist of an introduction, giving the natural history of the Diatomaceæ, with "a new classification based on their structure and mode of development," and of a synoptical portion, descriptive of British genera and species. We would remind Dr. Donkin of the statements concerning the Pinnulariæ made by Mr. Slack in a former number of THE STUDENT. It is evident that many of these organisms have been imperfectly figured because they were imperfectly seen. Those with what used to be considered irresolvable costæ require careful re-examination with Powell and Lealand's immersion 1-8th and 1-16th, and every nicety of illumination, to make out the true form of the markings, which seem quite complex with ordinary means. From Dr. Donkin's remarks, he will not be at all astonished at the extent to which these diatoms conform to navicula patterns; but there may be great difficulty in ascertaining what the markings on them really are.

Amongst the works on natural history translated from the French, we must notice the "Adventures of a Young Naturalist" of Lucien Birat, edited and adapted by Mr. Parker Gilmore, and published in a very handsome gift-book form by Messrs. Sampson Low and Co.* The unusual merit of the illustrations, their large number, and the general aspect of this work, are highly to be commended; but when we come to the letterpress our admiration is cooled down. A little boy of nine years old is supposed to accompany his father in a Mexican exploration, and to go through all sorts of adventures and meet with curious objects of various kinds. What he sees, what he does, what questions he asks on natural history, physical geography, etc., etc., and the answers he obtains, make up the book, which is intended to afford instruction in a very interesting way. We fear our young folks would not take this view of it, as it has none of the simplicity adapted to children, and is too obviously a manufacture to possess the charm of genuine travel or good fiction. The young Lucien is presumed to be fond of technicalities, and when an ant-eater appears and puts itself in a position of defence, he is told, to prevent

* "Adventures of a Young Naturalist," by Lucien Birat. Edited and adapted by Parker Gilmore, author of "All Round the World," "Gun, Rod, and Saddle," "Accessible Field Sports," etc., etc. With 117 illustrations. (Sampson Low and Co.)

alarm, that it is of the "order Edentata and akin to the Armadilloes." When he touches a salamander, and calls it "cold and sticky," he is informed that "the viscous humour which is secreted by the skin of *the salamander* is able to protect *them* for a short time from injury by fire, by means of the *same phenomenon* by which a hand, previously wetted, can be plunged into molten iron without burning it. Thus an idea has arisen that these batrachians can exist in the midst of flames." This passage contains bad science as well as bad English. The author or translator, whichever is answerable for the blunders, would not find that any "phenomenon" would protect his hand if he put it in the fire coated with a "viscous humour." He clearly does not understand Boutigney's experiment any better than he does grammar, or the proper meaning of phenomenon. In another place Lucien is told that meteors and aerolites are composed of "sulphur, chromium, and earth." When the boy finds an object "like a great sponge," he is informed that "it is a nest of white ants—they are insects of the neuropteral order, and allied to the bibellulæ," which must have been very intelligible to a child of his age, and equally so the statement that "the root of the dahlia is a farinaceous food of a somewhat insipid taste." It is a great pity when writers pay no attention to the proper force of words. An "insipid taste" is a *tasteless* taste—rather a curious article. In another place we find "artless ignorance," as if ignorance, or *absence* of knowledge, could by possibility be *artful*, or full of anything. In spite of its defects the book contains a considerable amount of information, and if the writing were as good as the engraving we could say more in its praise.

Dr. Cornwell supplies two excellent educational works, "Spelling for Beginners," and "Poetry for Beginners."* The spelling-book is founded upon the plan of introducing short sentences to be read by the pupil, containing words of the same character in sound as those in the margin, which are to be spelt. Information in pronunciation is also supplied, and when the same word has several meanings, attention is called to the fact by two or more asterisks. We should think children would readily be interested in this mode of teaching, and they would learn much quicker than in the old way. The poems for beginners are judiciously selected, some very simple and easy, others more difficult, but all good. Dr. Cornwell appends to each the name of the author, and the date at which, if dead, he lived, and

* "Spelling for Beginners; a Method of Teaching Spelling and Reading at the same time." "Poetry for Beginners; a Selection of Short and Easy Poems for Reading and Recitation in Schools and Families." (Simpkin and Co.)

notes to explain hard words. This unpretending cheap volume is a good introduction to English poetry, and we hope the schoolmasters and mistresses who use it will teach their pupils to read aloud, with due regard to both sense and sound—an accomplishment absurdly rare amongst all classes. The frightful sing-song most children are taught renders it impossible for them to appreciate poetry of any kind.

Dr. George Berwick writes on the "Forces of the Universe,"* a fine subject, worth better treatment. The author does not clearly apprehend elementary scientific facts and reasonings. He thinks the motion of pith balls between metal plates in a well-known electrical experiment "very analogous to the part which the particles of water evaporated from the earth's surface play in the outer world, in the first instance rising from the earth as aqueous vapour, and returning to it again by condensation in a visible form, at the same time carrying electric force upwards and downwards, and ever, amid the jarring elements, maintaining harmonious electrical equilibrium over the whole surface of the material universe." The light of the sun he thinks electrical, gravitation is electrical, and planets and sun, charged with opposite electricities, give light "in the same manner as when an arch of fire is produced, when the opposite poles of a galvanic or electro-magnetic machine are made to approach one another." In another place we are told that "if it were possible for the individual members of our planetary system to be contained in one large mass, or if their whole attracting force were combined in one power, and made to act simultaneously and in one direction upon the sun, it is quite possible that they would force the sun out of his present fixed position, and make him revolve round them." There is confusion of style as well as thought in this passage: if all the supposed powers were combined into *one* power, that single power would have nothing to act simultaneously with, except the sun, which is not what the writer means. The sun is not absolutely fixed, as he supposes, by an exact counterbalance of the opposing pulls at him made by his planets, and their mass altogether is so small compared with his, that they cannot *materially* change his position, though they must do so to an infinitesimal extent. The sun is not, as is subsequently stated, the *densest* body of the system. The solar density is stated by Sir John Herschel as about 0·2543 that of our earth. The sun's attractive power is 354,936 times that of the earth, and if the planets were all combined, the sun would far outweigh them, and if the supposed revolving motion took place, it

* "The Forces of the Universe," by George Berwick, M.D. (Longmans.)

would be round a centre of gravity near the sun, and not round the combined planets as a centre of the sun's revolution. Dr. Berwick supposes forces *identical* which are simply related or correlated. Electricity is not *identical* with magnetism or heat. Probably, to use Tyndall's phrase, all are modes of motion, but each has its own motion. With more thought, and a more distinct perception of what he is about, Dr. Berwick would appear to greater advantage in print.

We have to thank the managers of the Smithsonian Institution for sending us their Report for the year 1868, which contains a valuable selection of scientific papers on important subjects collected from various sources. The Smithsonian managers have been laudably active in extending their system of meteorological observations, and in re-establishing those which were interrupted by the slaveholders' rebellion. They hope to set up a well-equipped physical observatory at the highest point of the Pacific railway, at "Sherman's Station," which may facilitate the gradation of storms on the Atlantic coast. From a statement referring to agriculture, we learn that the Americans have been exhausting their soil to a greater extent than is generally known. "From a late account of the Commissioners of Agriculture, it appears the average yield of the whole United States is less than 12 bushels per acre, while that of Great Britain is 28." Land in the Eastern States which used to produce 30, and in some cases 40 to 50 bushels an acre, now produce but 8 or 10. The conclusion is that a more scientific system must be adopted.

The Proceedings of the Academy of Natural Sciences of Philadelphia, and the "Canadian Naturalist," contain valuable papers which our space does not permit us to analyse. In the former work Professor Leidy describes many new fossils, and amongst them a bone from Colorado of a beast resembling, and nearly as large as the Siratherium, and Professor Marsh exhibited a series of bird remains from U. S. cretaceous and tertiary rocks, showing this class to have been well represented in that country. The "Canadian Naturalist" contains a clever paper called "Aquaria Studies," describing the inhabitants of a Canadian tank; and then follow papers by Mr. Hunt on Laurentian Rocks, Laurentian Graphite, and the Norite or Labradorite Rock. Mrs. Reeks describes the birds of Newfoundland, and Mr. Bell its plants. There are other papers of interest.

The Rev. H. J. Martin* must excuse us if we do not depart from

* "The Christ of the Gospels." By the Rev. H. J. Martin. (Elliott Stock.)

our rule of declining to review theological works. We can only state that his book entitled "The Christ of the Gospels" belongs to the class of well-written liberal orthodox works.

Mr. Mackay contributes an "Apology for the Present System of Conveyancing," and though he states many things we do not agree with, his pamphlet will materially assist those who wish for law reform in matters pertaining to land, to see more clearly than many do at present what they are about.

PROGRESS OF INVENTION.

Fire-grates.—Mr. Padwick of Blaenau, Merioneth, has invented a method of increasing the current of air admitted to fires by a very simple contrivance. He places a grating on the bottom of the fire-grate, some short distance from the back, and then allows it to rest on the back, so that a triangular space, into which the fuel cannot get, is left; its three sides being formed by part of the bottom of the grate, part of the back, and by the perforated plate, which is of the full width of the fire-grate, and is about five or six inches high.

Preserving Wood from Decay.—By the process of Mr. Archibald B. Tripler, of New Orleans, wood is said to be preserved from decay in the following manner: The wood is cut into two or more equal parts, or slabs. These pieces are bored at equal distances to receive the tree-nails to unite them, and they are immersed in a solution of coal-tar and powdered charcoal, either hot or cold, in equal or unequal parts, which not only thoroughly impregnates the slabs with carbon, but coats the surface with an adhesive material, so that when put together their adjacent sides will adhere together, and form interior partitions, or walls of antiseptic or preservative agents, extending from one end of each slab to the other. These slabs are then united with tree-nails, or double pins, in such a manner as to lock them as firmly and solidly as if they were one piece. The timber thus prepared is immersed in a solution consisting of asphaltum, or mineral pitch, 80 parts; sulphur, 5 parts; arsenic, 5 parts; coal-tar, 5 parts; powdered charcoal, 5 parts;—in all, 100 parts. This solution will cover the surface, and fill up the joints and crevices between the slabs, rendering them impervious to water, and effectually preventing atmospheric decomposition by insulating it from the decaying influences of the elements.

Ventilating Mines.—This very important object is said to be

obtained in the following manner: A tube or pipe is introduced into the upcast shaft of the mine, or into the shaft, or portion of the shaft which is used as an outlet for the air, and for the gases generated or evolved in the mine. The tube, or pipe, is carried nearly to the bottom of the shaft, the upper part being carried to some height above the level of the pit's mouth. Into the upper part of the tube, or pipe ordinary, super-heated steam derived from any suitable source is introduced, and thereby a vacuum, or partial vacuum produced, to supply which the air contained in the workings of the mine is necessarily set in motion, and flows in a continual current from all parts of the mine towards the vacuum, or partial vacuum, and carrying with it the noxious gases or vapours which have been generated or evolved, such current being continued as long as the steam is supplied to the ventilating tube. Several tubes may be employed. The advantages of the process are said by the inventor, Mr. Horsfall, to be cheapness and completeness.

PRODUCING OXYGEN GAS.—Dr. Kirkpatrick, of Brussels, has patented the following method of obtaining oxygen in quantities, and at a small cost: Any hydrated oxide, or any hydrated salt, or other hydrated compound of cobalt or nickel, or any mixture of these substances in a comparatively small proportion, is used with a larger quantity of any soluble hypochlorite, such as hypochlorite of lime or potash. This compound of cobalt or nickel coming into contact with the hypochlorites, decomposes them; a black precipitate is formed, and this acts on the hypochlorite, setting free oxygen from it. The oxygen gas thus set free escapes with effervescence, and may be collected, in the same manner as hydrogen or carbonic acid, in a gas receiver. The inventor prefers to use hypochlorite of lime, the substance known as chloride of lime, or bleaching powder. When a solution of this salt is used, it should be in a concentrated form, so as to reduce the bulk of the liquid. When it is used in the state of bleaching powder, it should be made into a milk by mixing it with a certain quantity of water. Cobalt salts are said to act better than those of nickel, they being more prompt and quick in causing the decomposition. The nitrate or chloride are the best. The cobalt salt should not be acid, otherwise chlorine will be evolved. When the evolution of oxygen has ceased, the cobalt falls to the bottom as cobaltic oxide. The supernatant liquid may then be drawn off, and a fresh quantity of liquid chloride of lime may be poured in, and this process may be continued till the oxide has lost its efficiency. The same quantity of oxide will often decompose successive additions of chloride of lime almost indefinitely, but when

the oxide has lost its efficiency, it may be easily restored by transforming it into a salt in the usual manner, care being taken to make the salt neutral. When a turbid solution, or a mixture of bleaching powder with water, has been used, the cobaltic oxide will necessarily be mixed with solid particles, but it may be readily separated from them by adding to the mixture an acid (hydrochloric is preferred) till it assumes an acid reaction. The cobalt is then dissolved, and carbonate of lime should afterwards be added till the acid is neutralized. The cobalt will now be in solution in the liquid, which may be drawn off, and the cobalt precipitated from it by lime or by any other precipitant usually employed, which forms soluble compounds with lime. If hydrochloric acid has been used as a solvent, chloride of lime is a very convenient precipitant. With respect to the proportion of the cobalt compounds which should be used to liberate the oxygen from a given quantity of chloride of lime, the cobalt compound added to the chloride of lime should be in such proportion as to contain from three to ten parts by weight of metallic cobalt to every thousand parts by weight of chloride of lime, marking 100° of Gay Lussac's scale. Less may be used, but the evolution of the gas will be slower. A too large proportion of cobalt should be avoided as it passes to the state of the higher oxide at the expense of the oxygen of the chloride of lime, and, if equivalent proportions are used, chloric would alone be evolved without any oxygen being given off.

OVENS AND KILNS.—Messrs. Brough thus describe their method of making kilns and ovens: We construct our ovens and kilns of a circular or elliptic sectional plan, but the principle of construction may be used in different forms. The interior of the chamber is constructed with a series of nearly equal-spaced descending flues, which, communicating with the principal flue from the fires, and leading into flues along the floor of the oven, pass all into one great flue up the centre of the chamber. By this arrangement the heat is not only made to circulate through every part of the oven—top, sides, bottom, and interior—but the smoke is kept from actual contact with the goods during their action in the kiln.

STOPPERING BOTTLES, ETC.—A hollow, cylindrical plug, tapering towards the bottom, is made of gutta percha, wood, or other suitable material, and its lower end is divided into segments, so as to be capable of expansion or compression, by the application or withdrawal of a conically-formed screw or wedge. The inner surface of the plug is tapped to receive the screw. Around the outer surface of the plug is placed a ring or surface of india-rubber. In using

this stopper the plug is first inserted into the neck of the vessel, and then the screw is used to expand the plug. The plug may be of any desired shape. The inventor is Mr. John Underwood, of Archway-road, Highgate.

FIRE-BARS.—The object of this invention is to construct fire-bars in such a way that the upper part, which is more directly exposed to the heat, may be replaced when burnt away or unfit for use, while the other or lower part may last and be available for a very much longer time. The upper and lower part are dovetailed, or otherwise suitably joined together by projections on one fitting into corresponding cavities in the other bar, in such a way that the fit is quite loose and easy when the bar is cold, but sufficiently tight when the bars are hot, to prevent warping or other inconveniences, the upper part expanding to a greater extent than the lower. The under part, where it is joined to the upper, may be scolloped, cut out, notched, or perforated, for the air to pass right through. The lower part may be hollow, or in two parts or sides, with a space between them.

GYMNASTIC APPARATUS.—A new and safe gymnastic apparatus has been invented by W. Hanlon, of New York. This apparatus is constructed so as to consist of parallel bars and swings, so arranged that the distance between the bars may be varied at pleasure, so that the performer can either rest on them or pass freely between them without danger of striking against them, and that he may be able to stop or start swinging at pleasure. It consists of parallel bars, secured laterally by means of two sets of cross-bars or braces, placed at proper distances apart, and held firmly in mid air by any suitable means. On one set of these bars are arranged, two on each bar, small swings, and a single trapeze is attached to each bar of the other set. The variation in the distance between the parallel bars is obtained by means of flaps or rests hinged on to the parallel bars, the object being to allow in some feats of one performer catching and resting on the flaps while another swings on the trapeze, and grasps him by the feet. In any feat where the flaps are not required they can be turned over out of the way, so as to present the entire length of the bars perfectly clear. The stopping and starting arrangement consists of two pairs of short ropes, which are designated stop-ropes, pendant from the parallel bars, and placed about midway between the cross-bars or braces which carry the small swings and trapezes, the object of these stop-ropes being to enable the performer, while swinging,

to stop and start himself quickly and without much effort. In addition to this there is also, as part of the invention, a safety apron, to be used in connection with it. It is arranged as follows: An apron of cloth or canvas is employed; with it are combined cross-stays or ribs, or slabs of wood, or other elastic suitable material, placed at short distances apart. The apron is drawn over short trestles, and is secured to the floor or walls of the apartment by means of tension cords, fastened to a strong bar at each end of the apron, and converging to a common centre, where they are united to single cords and pulley blocks in the usual way. By sewing, or otherwise securing the cross-stays or slabs to the apron, it is rendered capable of resisting any tendency to throw or allow the performer to slide on to the floor, should he by some mischance fall near the edges or sides of the apron.

MEMORANDA.

THE ACTION OF WIND ON THE BAROMETER.—M. W. De Fonvielle called the attention of the French Academy in September, to the following remarks of Mariotte, in the first volume of his works, printed at Paris in 1740:—"The north and north-west winds ordinarily cause the mercury of the barometer to rise, not only because they render the air more heavy, but also because, in blowing against the earth from above downwards they augment its elasticity, and that raises the mercury. The barometrical oscillations which accompany south and south-west winds receive an analagous explanation. The south and south-west, which come from afar, often blow in tangents to the north, and raise the air upwards, diminishing its elasticity."

APPEARANCES OF JUPITER.—On the 24th and 25th October Mr. Browning made two careful drawings of Jupiter, one at 11 p.m. and the other at 10.45, thus obtaining representations of the whole surface of the planet. He found the equatorial belt "of a fuller ochreish, or tawny colour" than on a former occasion; north of the equator was a bright belt, being the brightest part of the planet, and the dark belts on the northern side were dark brown, with less copper tint than on previous observations. South of the equator the disc was particularly free from belts. These remarks apply particularly to the night of the 24th. The hemisphere seen on the 25th had a bright and a dark belt about midway between the south pole and the equator; the ochreish belt was mottled all over with cloudy white marks; a distinct line of them, though separated by darker markings, evidently encircled the whole planet a little way to the south of the equator. Two photographs taken within a quarter of an hour of

the same time on the 24th, by Mr. De la Rue, show the equatorial belt almost absolutely transparent, the light from the orange-coloured belt having failed to act on the sensitive plate. Mr. Browning says that he has seen photographs taken at other times, in which this belt exerted the most action. We have taken these particulars from a paper read by Mr. Browning before the Astronomical Society.

ACKLAND'S SELENITE STAGE.—Mr. Ackland (Horne & Thornthwaite) has just designed and brought out a very clever and handy selenite stage, which will replace elaborate and expensive contrivances now in use for obtaining a variety of tints for polariscope objects. Mr. Ackland found that a neutral tint like that of Newton's rings midway between the violet of the second wave and the indigo of the third wave, had an extremely delicate and advantageous action, producing remarkably gorgeous colours with suitable objects. He prepares selenite films of the exact thickness, and microscopists can be supplied with an apparatus of three or four rotatory films at a very moderate price.

PORTABLE LAMPS.—Mr. Fiddian has devised a good portable microscope lamp, which can be carried in the pocket. It is made by Mr. Browning, and will be much liked by travelling microscopists. Its principle is the same as his previous lamp with the metallic chimney, and the arrangements are very convenient and complete.

Mr. Moginie has also devised a cheap and handy portable lamp, which goes into a rather smaller compass than Mr. Fiddian's, and has the ordinary glass chimney. Mr. Fiddian's is the most elaborate and necessarily higher in price. Both pack conveniently.

MR. PROCTOR'S "OTHER WORLDS."—We are glad to find this remarkable work already in its second edition. In his preface Mr. Proctor notices various unfair reviews, especially one by Professor Pritchard, which was a most ridiculous exhibition of clerical conservatism misapplied to science. The professor deserves his castigation; but articles so silly ought not to receive any attention from a man of Mr. Proctor's standing.

THE ECLIPSE IN ENGLAND.—Mr. Slack writes that the eclipse was on the whole well seen on Ashdown Forest (Sussex), although at the moment of first contact clouds rose in the way. A thermometer in the sun just before the eclipse began fell nine degrees at its height. The entire moon's disc was visible in a 3-inch refractor with power of 50, and dark glass at 12.45, and of dull, coppery grey; the dark glass giving a neutral tint, grey, and diminishing the red of the moon.

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